Total Maximum Daily Load Studies in Receiving Waters in Accomack County

Public Meeting

July 18, 2012

DEQ Virginia Department of Environmental Quality

William & Mary VIMS

Why We Are Here

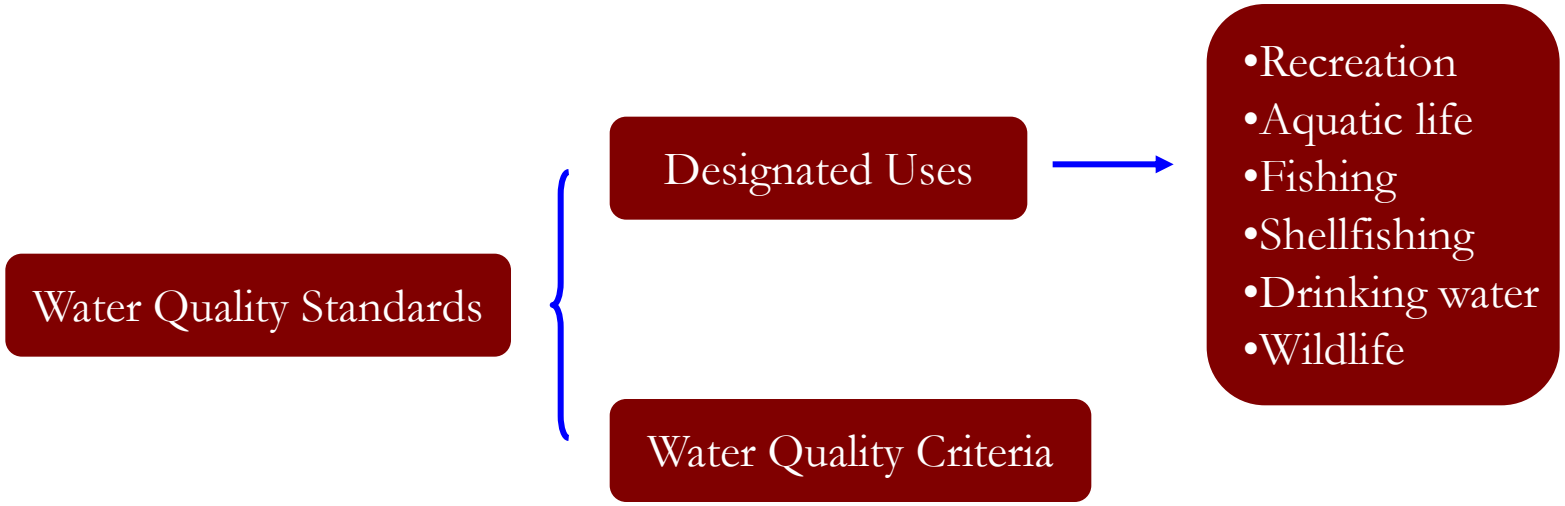
1. To learn about water quality of the stream
2. To discuss the Total Maximum Daily Load (TMDL) development
3. To gather comments and encourage public participation

Outline

- The TMDL process
- Impaired waters and pollutants
- Procedures of pollutant source assessment
- Developed modeling approach
- Preliminary TMDL results
- Comments

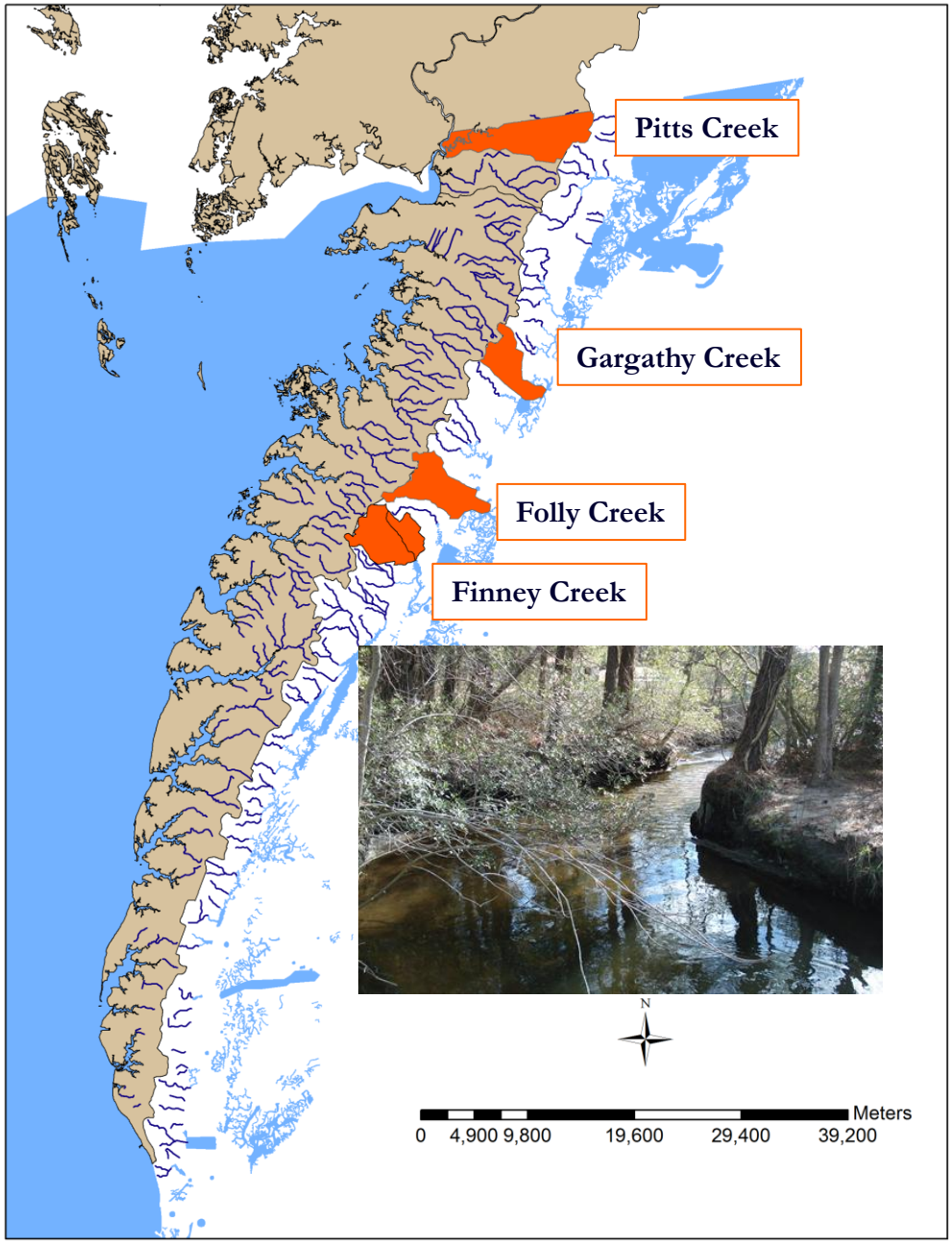
The TMDL Process

- DEQ routinely monitors the quality of waters across the state and publishes a list of impaired waters every 2 years
- Virginia is required by law to establish a TMDL for each pollutant causing an impairment
- A TMDL is the amount of a particular pollutant that a stream can receive and still meet Water Quality Standards



Impaired Waters and Pollutants

- Unnamed tributary to Pitts Creek (bacteria and pH)
- Gargathy Creek
  - Upper and lower estuarine portions (dissolved oxygen)
  - Riverine portion (bacteria, benthic)
- Folly Creek
  - Folly Creek-Upper and middle estuarine portion (dissolved oxygen)
  - Unnamed tributary (benthic)
  - Ross Branch (benthic)
- Finney Creek-Upper (bacteria)



Pitts Creek

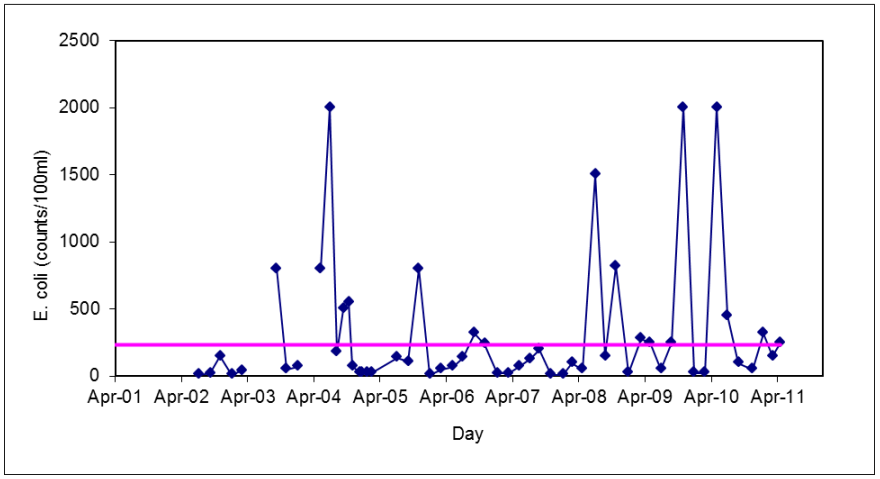
Gargathy Creek

Folly Creek

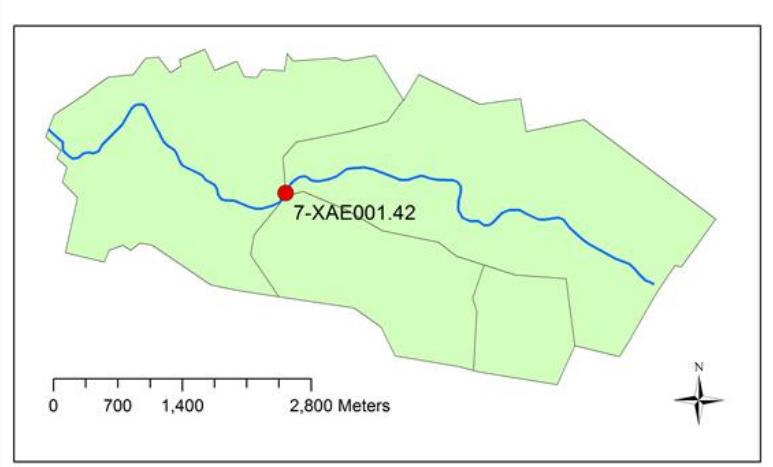
Water Quality Criteria

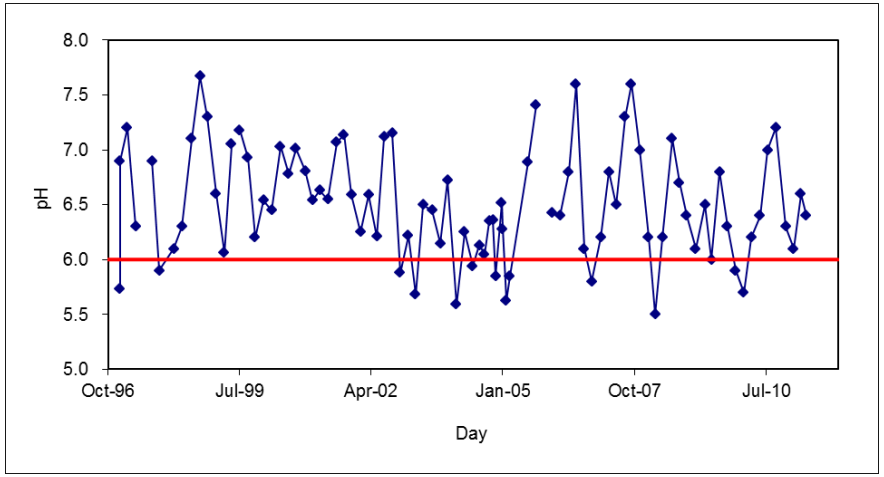
Water Type		Criteria
Class II (tidal water) Class III (freshwater)	Dissolved oxygen	Minimum: 4 mg/l; Daily Average: 5 mg/l
	E. Coli (freshwater)	Geomean 126 counts/100ml Single Sample Max. 235 counts/100ml
	Enterococci (salt water)	Geomean 35 counts/100ml Single Sample Max. 104 counts/100ml
	pH	6 - 9

Violation Verification
Pitts Creek (pH and bacteria)



Violation 33%

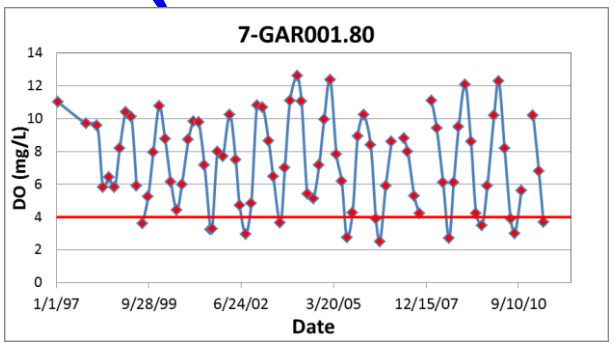


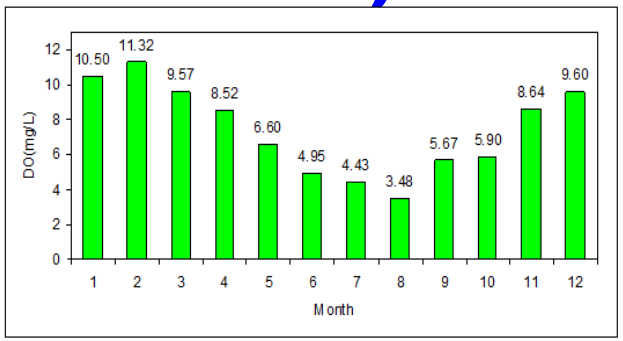


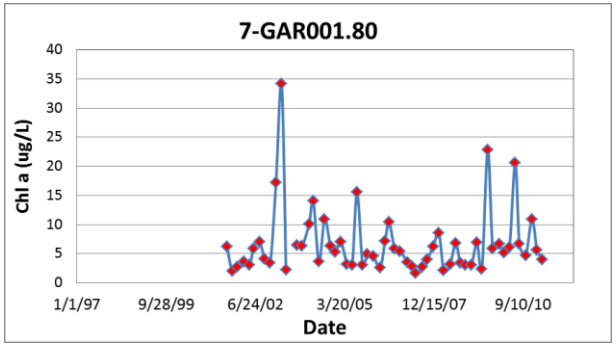
Violation 17%

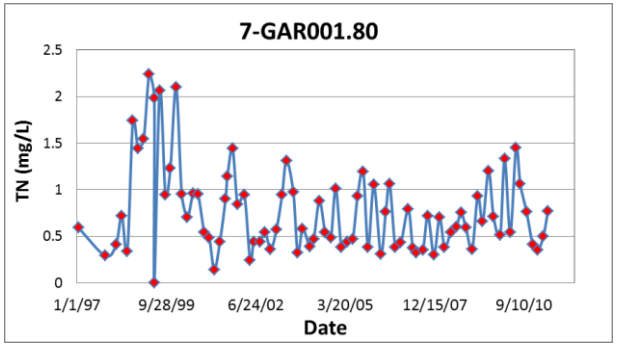
Gargathy Creek (DO and bacteria)

Violation =16.2%

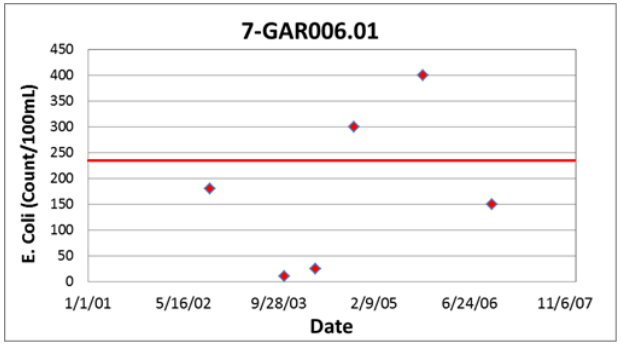


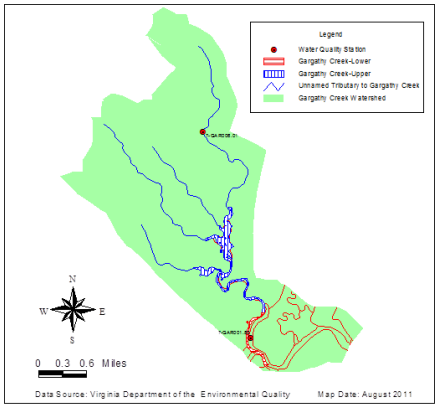






Violation =33.3%





Folly Creek (DO)

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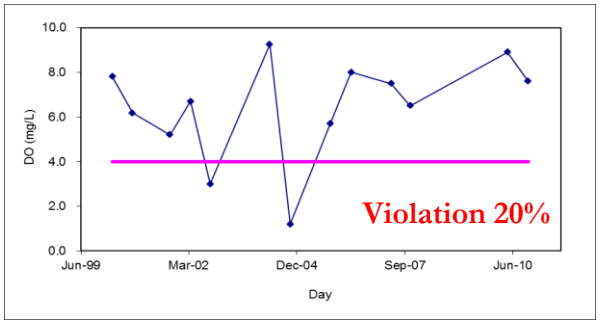

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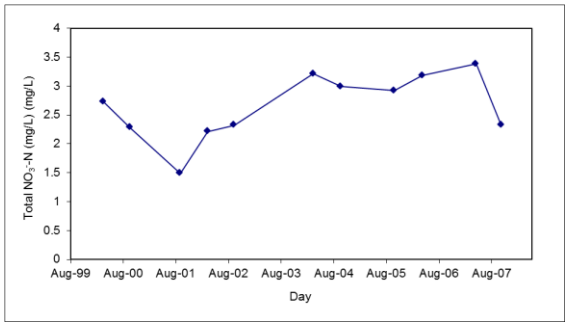

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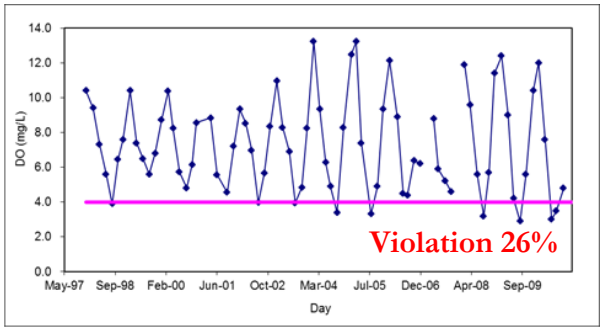

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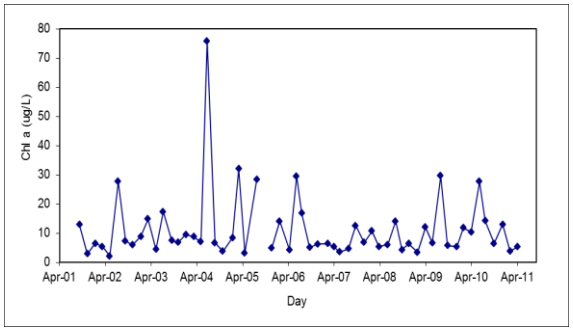
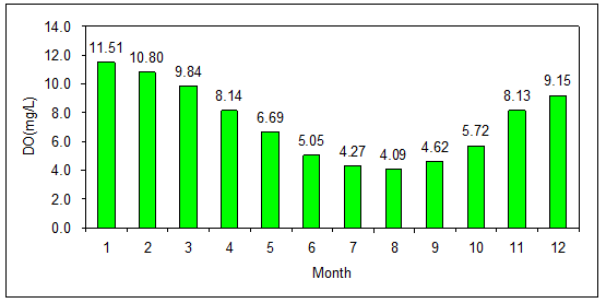
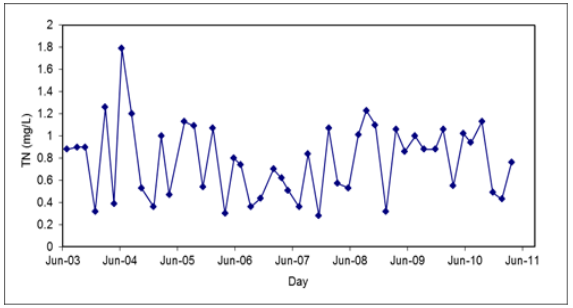
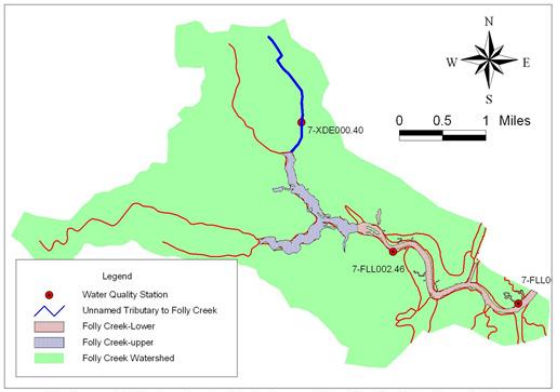


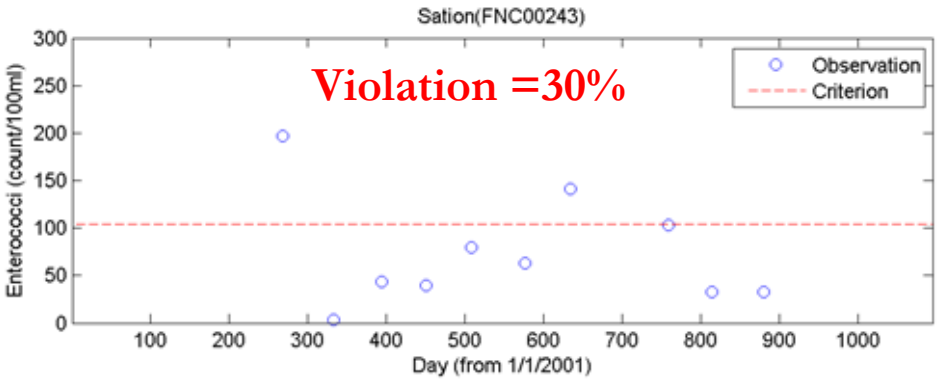


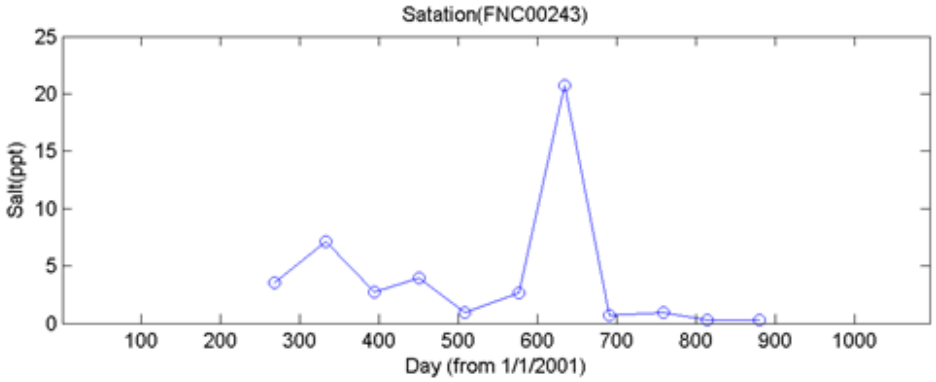


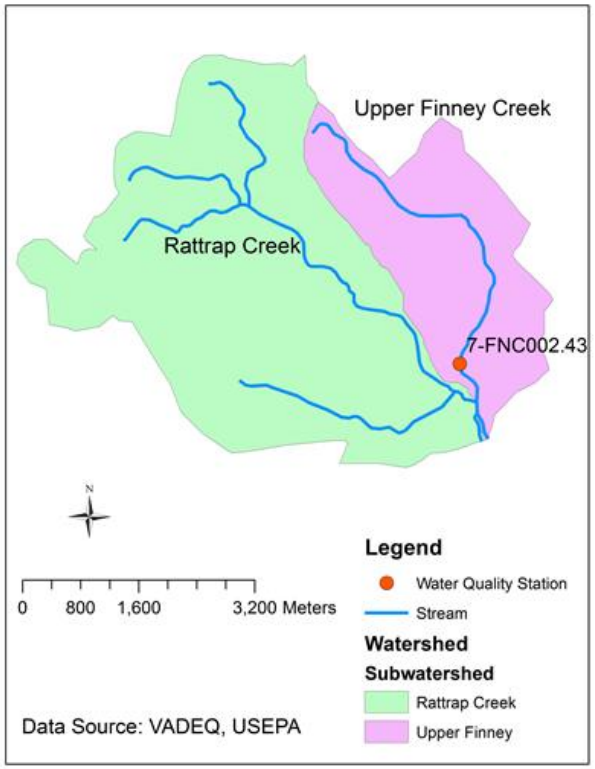


Data Source: Virginia Department of the Environmental Quality Map Date: August 2011

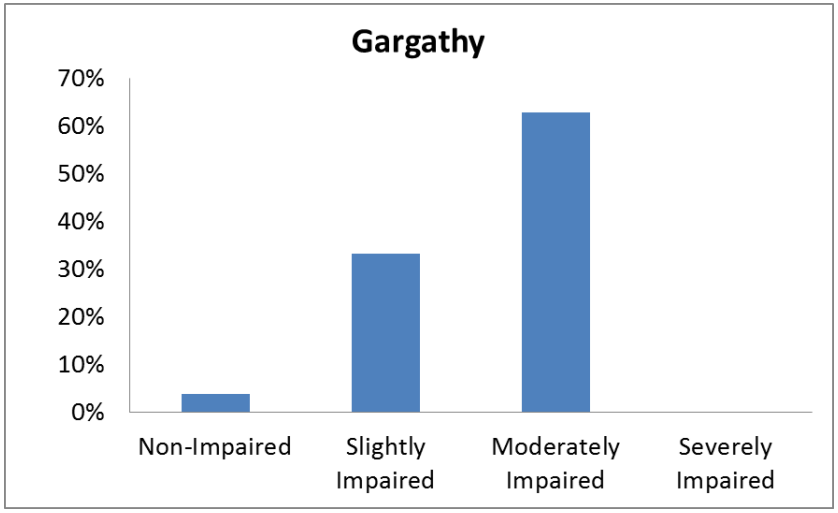
Finney Creek (bacteria)

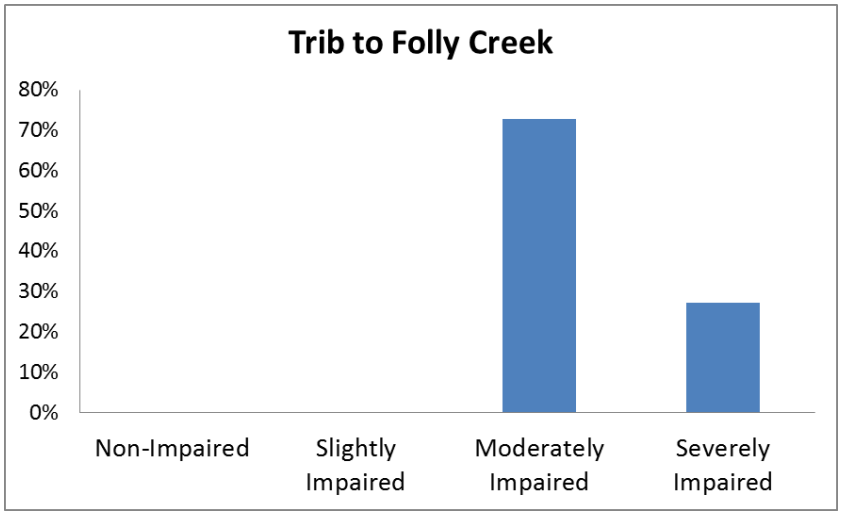


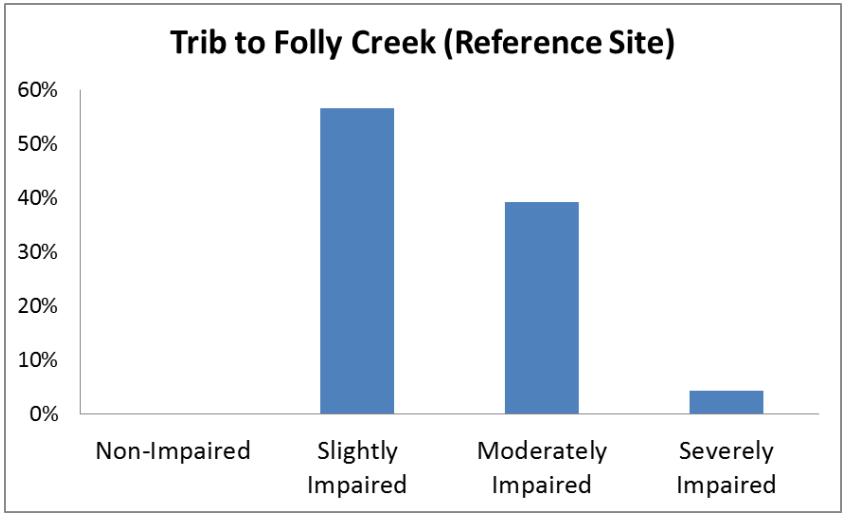


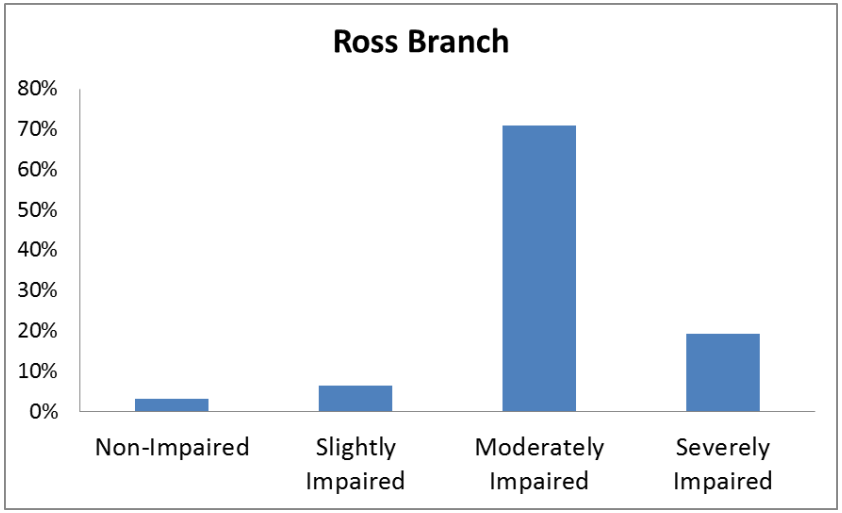


Benthic Impairment





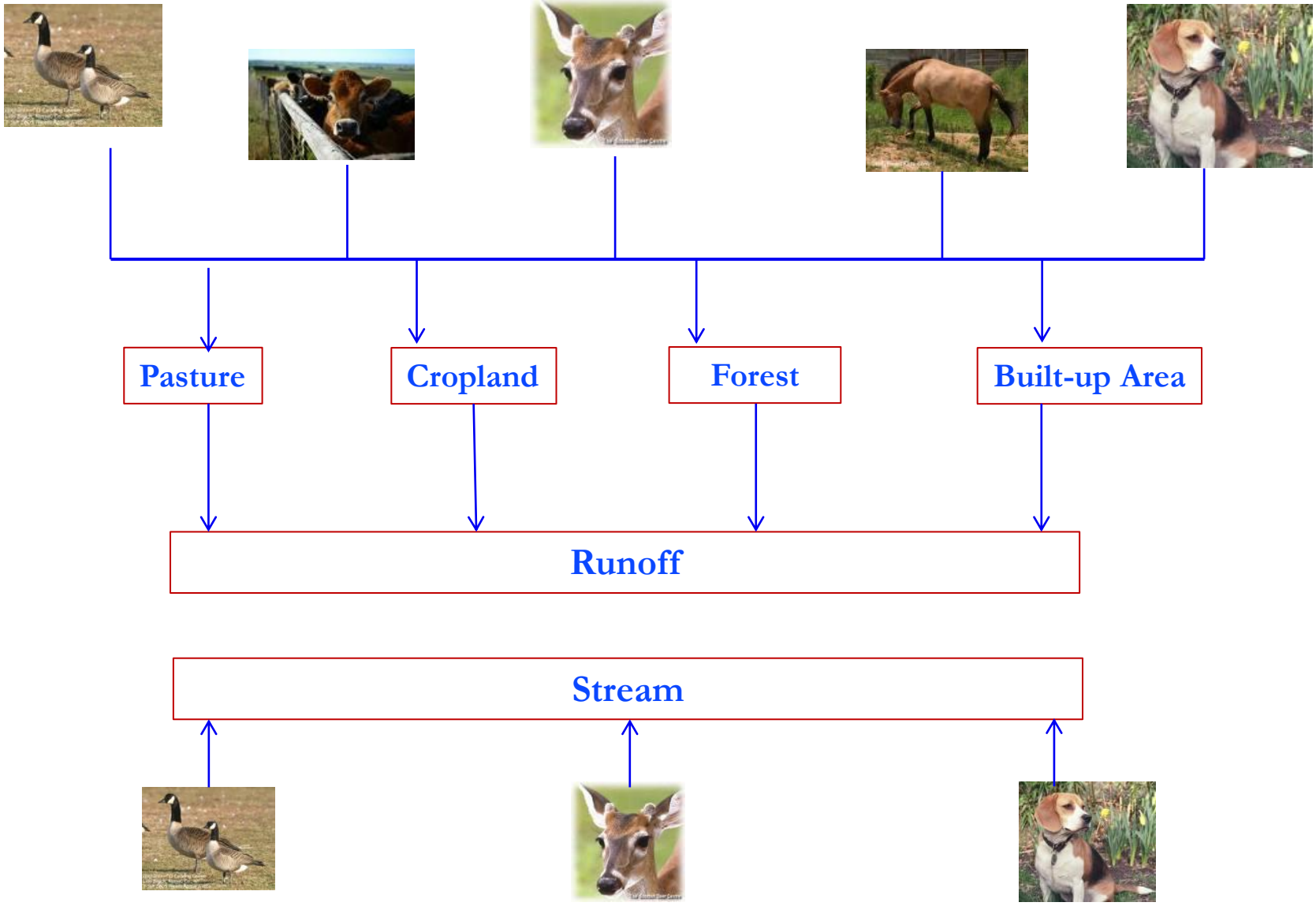




Procedures of Pollutant Source Assessment

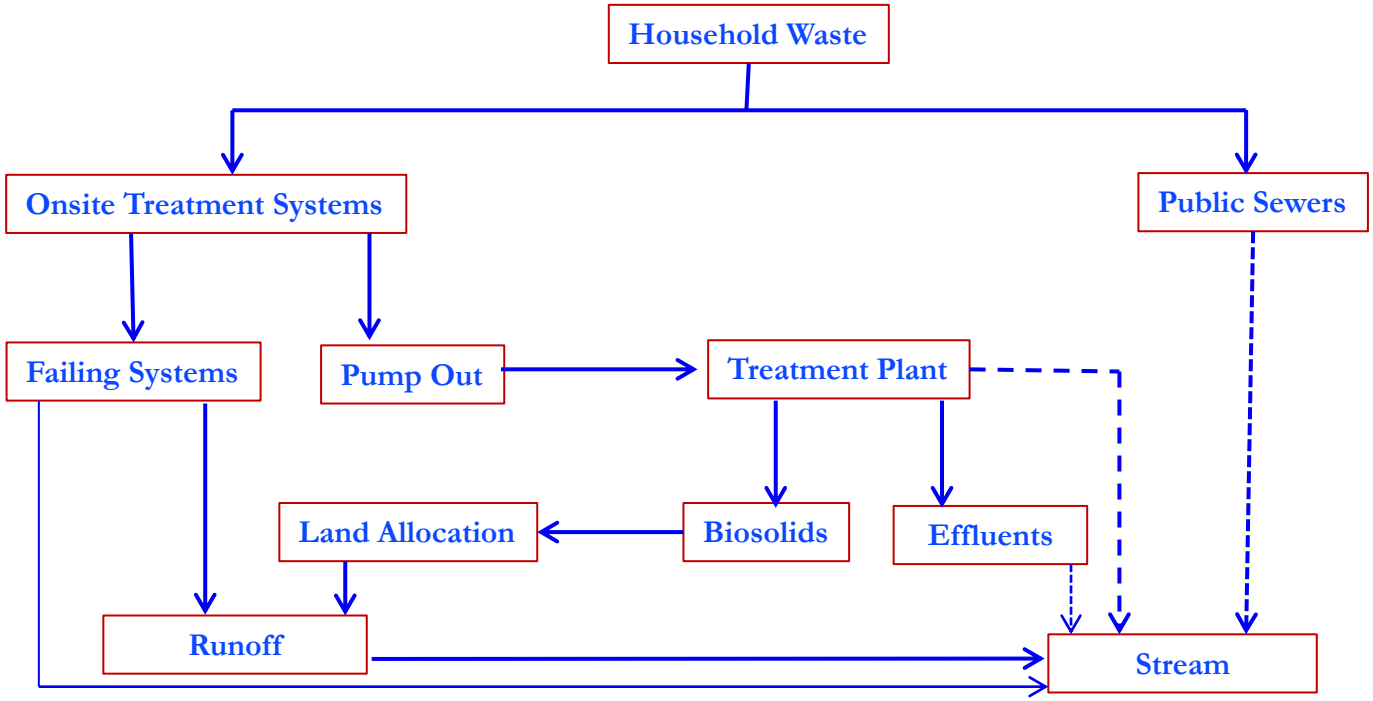
- Sources
  - Agricultural
  - Humans
  - Pets
  - Livestock
  - Wildlife
- Approach
  - GIS land use data (land use, population, pets, septic systems)
  - Wildlife survey data (animal density, animal habitat)
  - Shoreline survey data
  - Field survey
  - Public meeting
  - Interview

Potential Sources: Wildlife, Livestock, and Pets

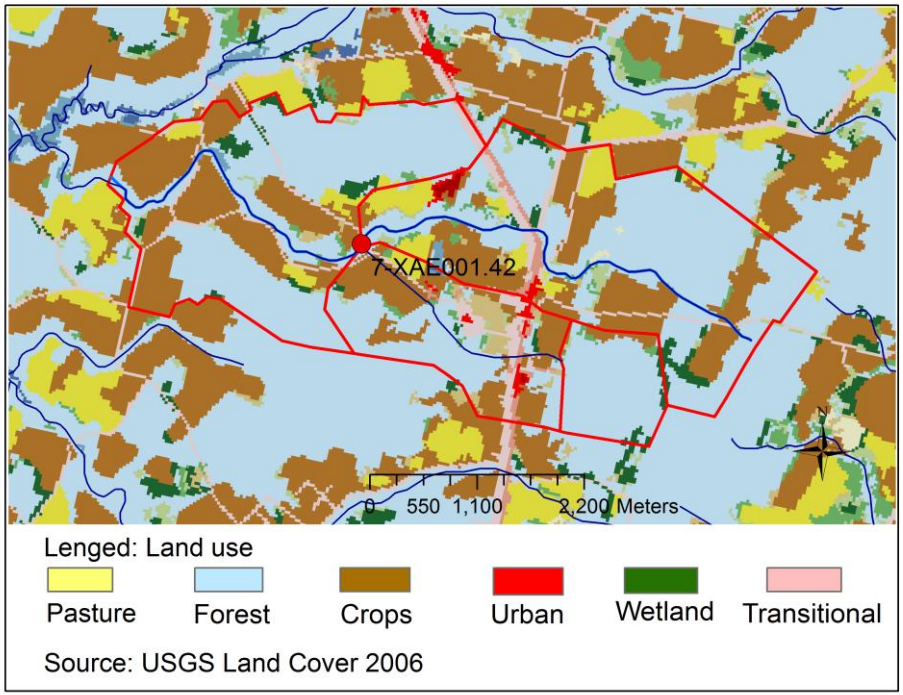


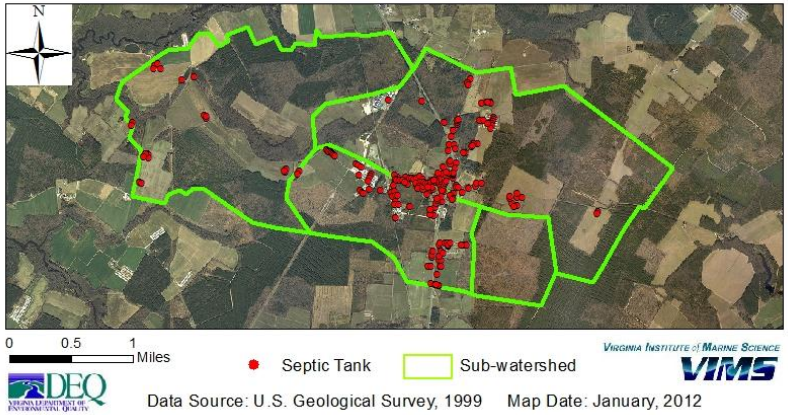
Source Assessment

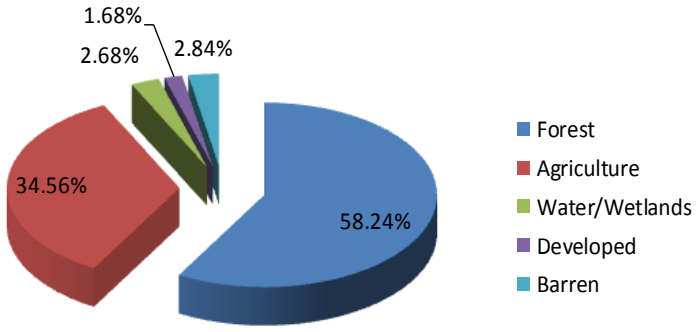
Human Contribution
(bacteria and nutrients)



Pitts Creek Loading Estimation







Pitts Creek Loading Estimation

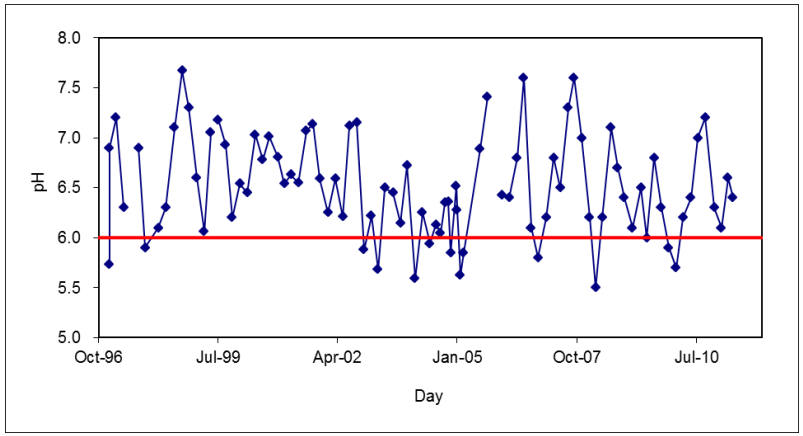
Sub-watershed		1	2	3	4
Humans		185	211	37	85
Dogs		43	49	9	20
Livestock	Cattle	3	2	<1	1
	Swine	7	7	<1	3
	Horses	1	1	<1	1
	Sheep	1	<1	<1	<1
	Chicken	29,280	28,132	1,776	11,124
Wildlife	Ducks	19	21	4	9
	Geese	45	51	9	20
	Deer	50	54	9	21
	Raccoons	70	80	14	32

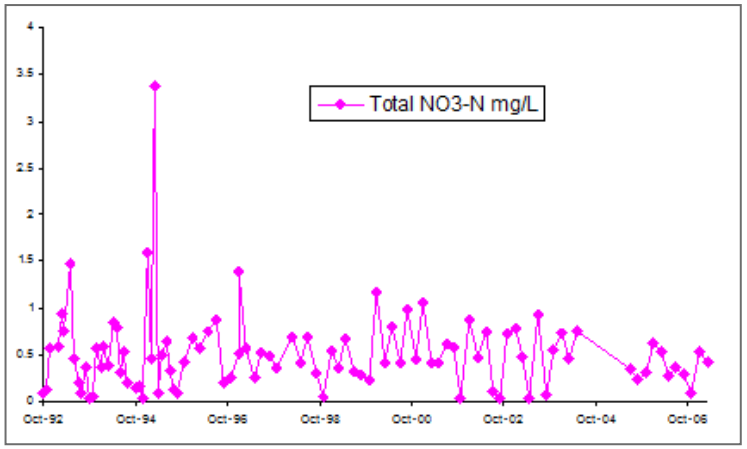
Manure application - 52 tons/year

Fecal Coliform Source	Loading Counts/day	Loading Percent
Livestock	1.20E+12	15.48%
Wildlife	6.35E+12	82.06%
Human	5.95E+08	0.01%
Pet	1.90E+11	2.45%
Total	7.73E+12	100.00%

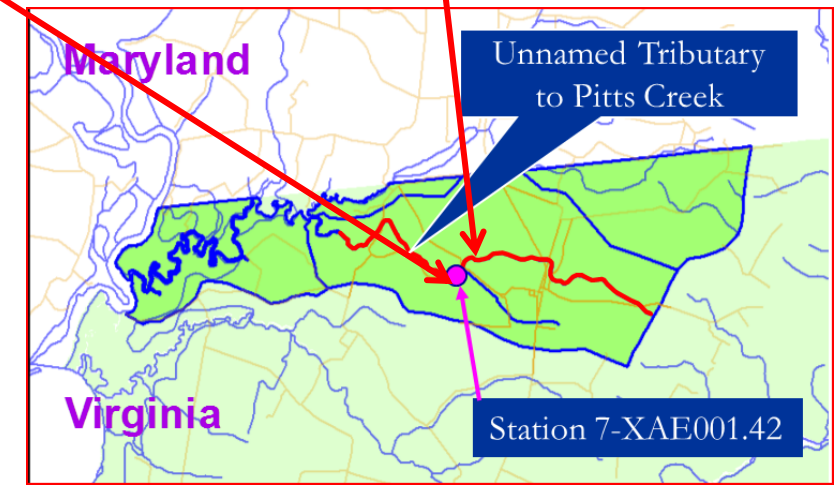
Natural Condition of Low pH

- Low pH occurs due to decay of vegetative materials (forest, marsh, wetland) to produce organic acids
- Conditions in a stream that would typically be associated with naturally low pH include slow-moving water, ripple-less waters
- These situations can be compounded by anthropogenic activities (excessive nutrients or pollutants)



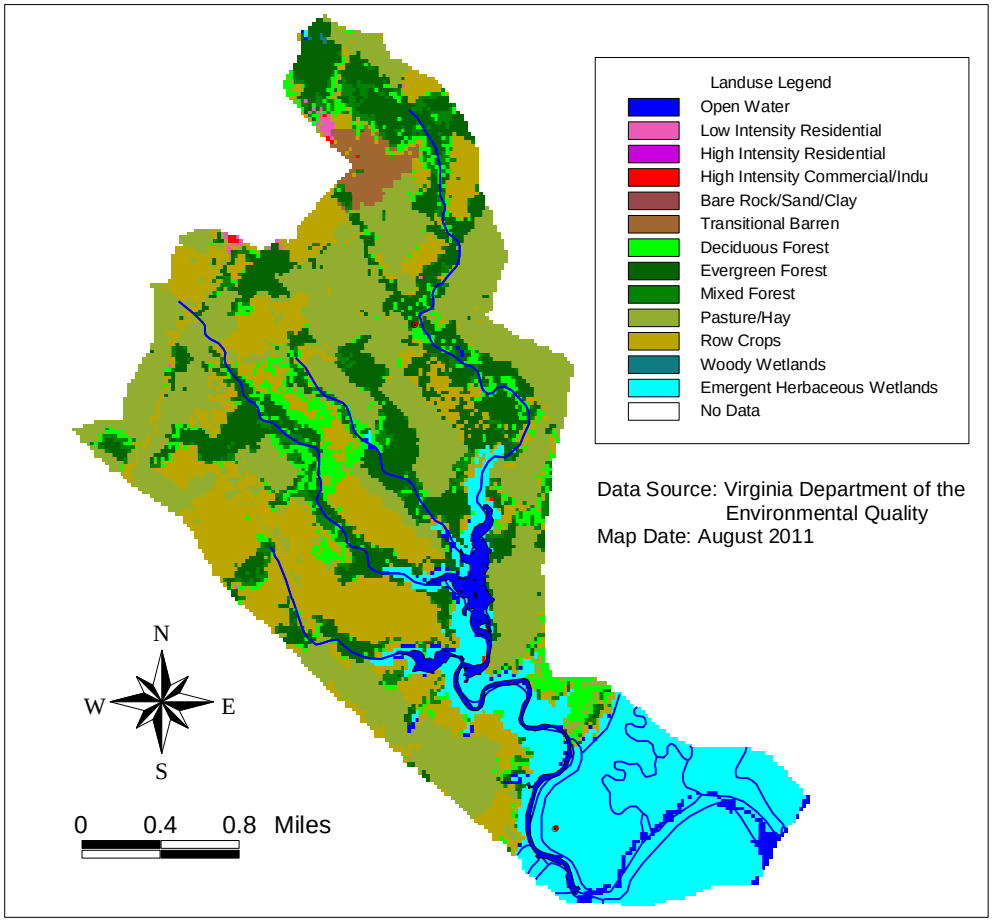


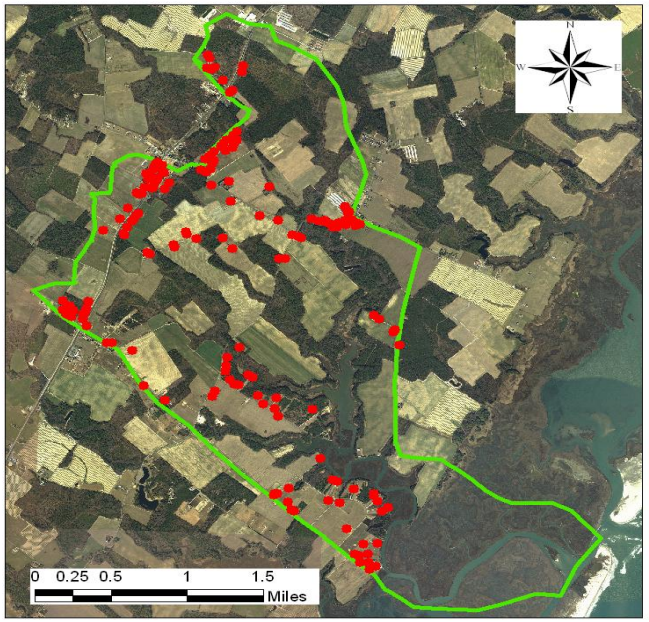
Pitts Creek



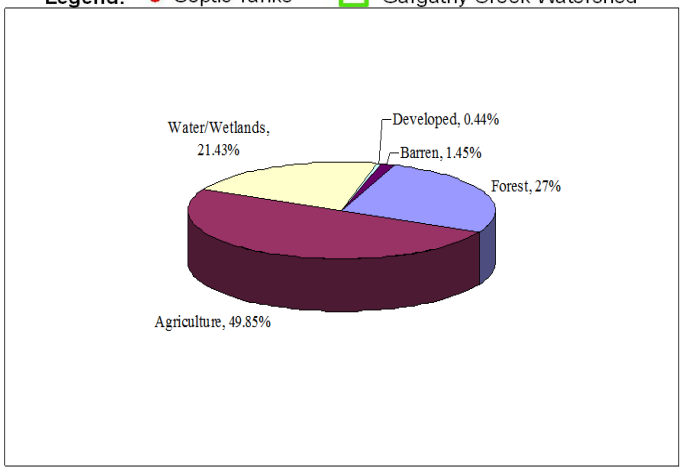
Very slow-moving water during low flow condition creates a swamp environment

Gargathy Creek Loading Estimation





Legend: Septic Tanks Gargathy Creek Watershed



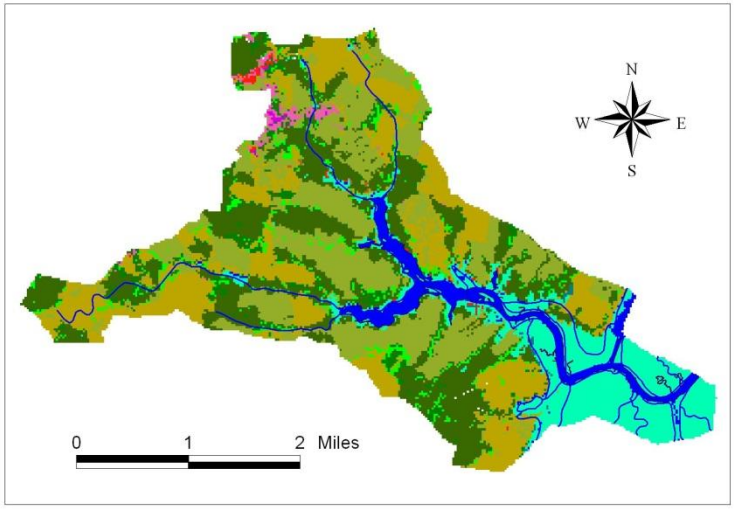
Gargathy Creek Loading Estimation

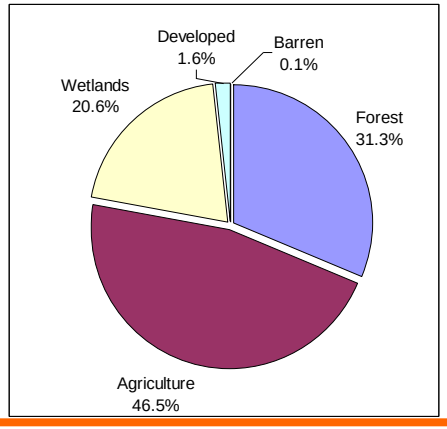
		Totals
Humans		494
Dogs		139
Cat(unused)**		157
Livestock	Cattle	12
	Swine	0
	Chickens	134390
	Horses	7
	Sheep	6
Wildlife	Ducks	9
	Geese	96
	Deer	200
	Raccoons	101
	Muskrat	361
	Nutria	212

Category	Source Allocation
Livestock	58.98%
Wildlife	39.49%
Human	0.01%
Pets	1.51%
Total	100.00%

Manure has been applied to about 49 acres of cropland based on CAFO inspection

Folly Creek Loading Estimation





Category		Totals
Human		717
Dog		202
Cat (Data Unused)		227
Livestock	Cattle	17
	Swine	0
	Chickens	207395
	Horses	9
	Sheep	7
Wildlife	Ducks	13
	Geese	139
	Deer	282
	Raccoons	129
	Muskrat	446
	Nutria	262

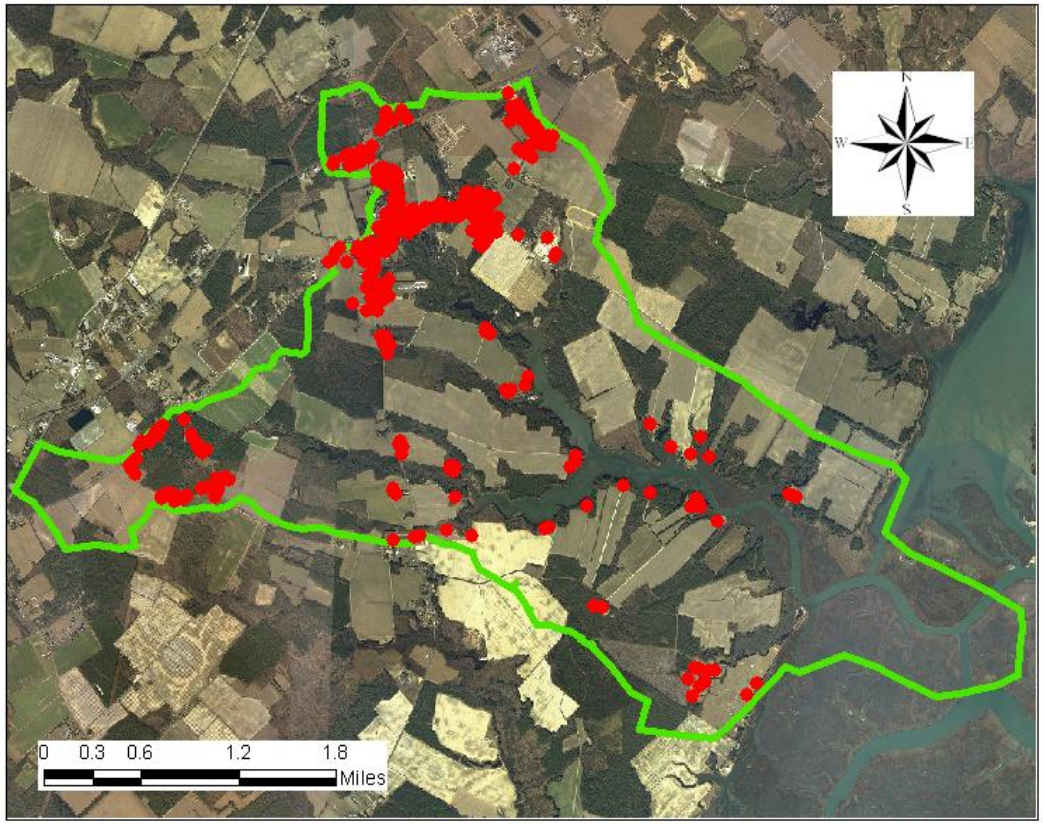
***Chicken total is estimated using land use data**

Folly Creek Loading Estimation

Bacteria Sources

Category	Source Allocation
Livestock	25.52%
Wildlife	72.54%
Human	0.02%
Pets	1.92%
Total	100.00%

No manure application!

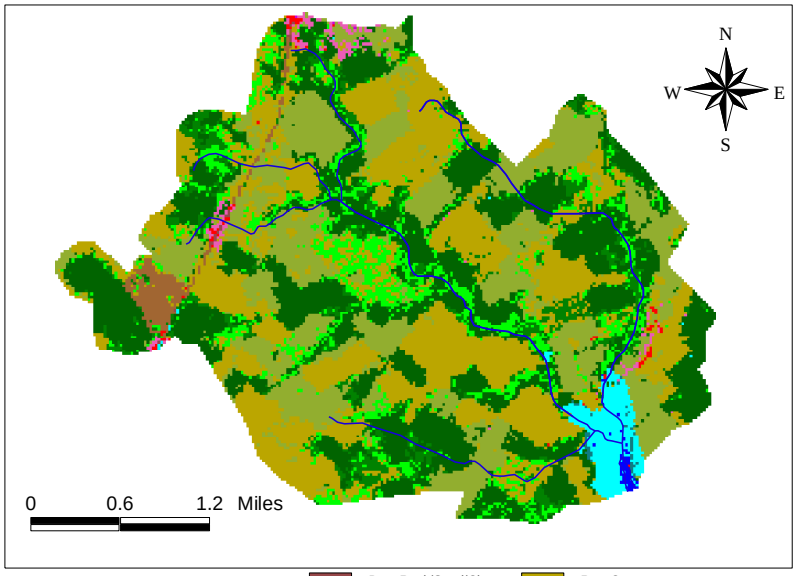


Legend: Septic Tanks Folly Creek Watershed

Data Source: U.S. Geological Survey.1999 Map Date: Sep. 2011

Septic Tanks

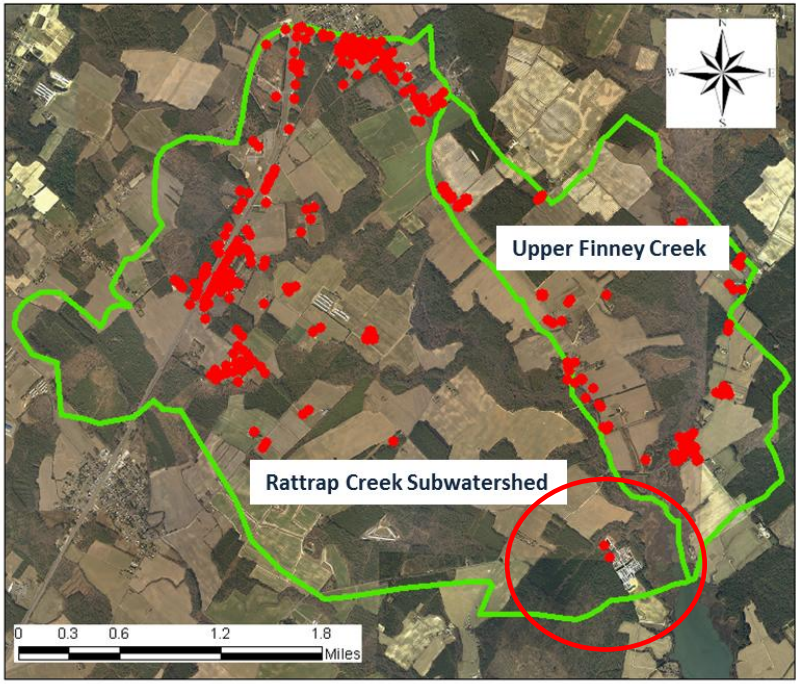
Finney Creek Loading Estimation



Landuse Legend

- Open Water
- Low Intensity Residential
- High Intensity Residential
- High Intensity Commercial/Indu
- Bare Rock/Sand/Clay
- Transitional Barren
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Pasture/Hay
- Row Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands
- No Data

Data Source: Virginia Department of the Environmental Quality Map Date: August 2011



Legend: Septic Tanks Watershed

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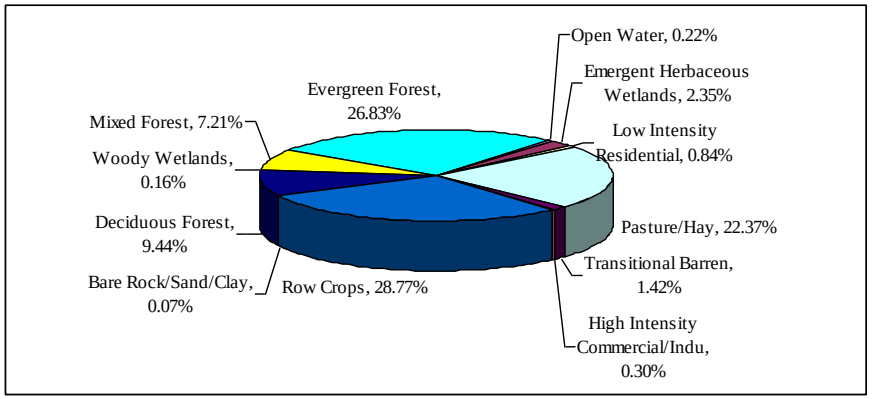


Finney Creek

		Finney Creek watershed	Rattrap Creek watershed	Entire watershed
Humans		200	528	728
Dogs		56	149	205
Cat(unused)**		63	168	231
Livestock	Cattle	5	13	18
	Swine	0	0	0
	Chickens*	64473	198926	263399
	Horses	3	5	8
	Sheep	2	5	7
Wildlife	Canada Geese/Snow geese	7	19	26
	Residential Geese	70	186	141
	Deer	163	430	741
	Raccoons	34	81	115
	Muskrat	109	231	340
	Others	0	0	0

Waterbody Name	Source	Percent of Source
Upper Finney Creek	**Livestock**	9.85%
	Wildlife	88.94%
	Human	0.01%
	Pets	1.20%
	Total	100.00%
Rattrap Creek	**Livestock**	10.92%
	Wildlife	87.88%
	Human	0.01%
	Pets	1.19%
	Total	100.00%

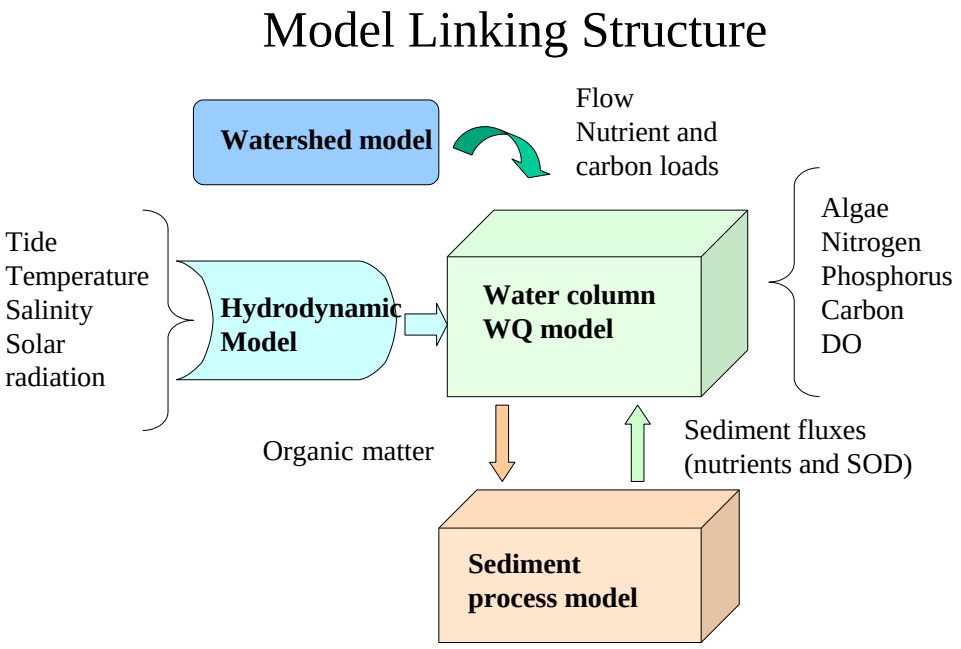
No manure application in this watershed !

Other Nutrient Sources

- N-fertilizer applied to the cropland is 125 lb/acre/year
- Nutrient contribution from atmospheric deposition
  - TN =11.48 lb/acre/year
  - TP =0.71 lb/acre/year

Modeling Approach

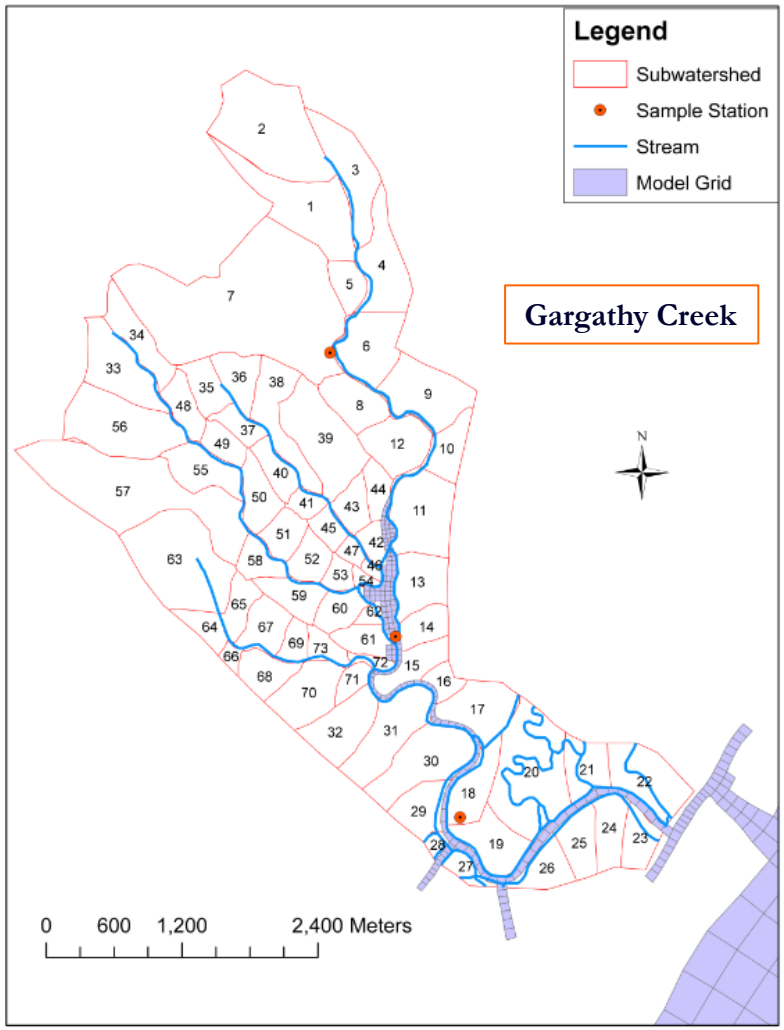
- Conduct source analysis
  - Estimate nutrients or bacteria sources
  - Use LSPC to simulate watershed processes
- Use a spatially varying water quality model (EFDC)
  - Simulate in-stream DO processes
  - Simulate bacteria transport and fate

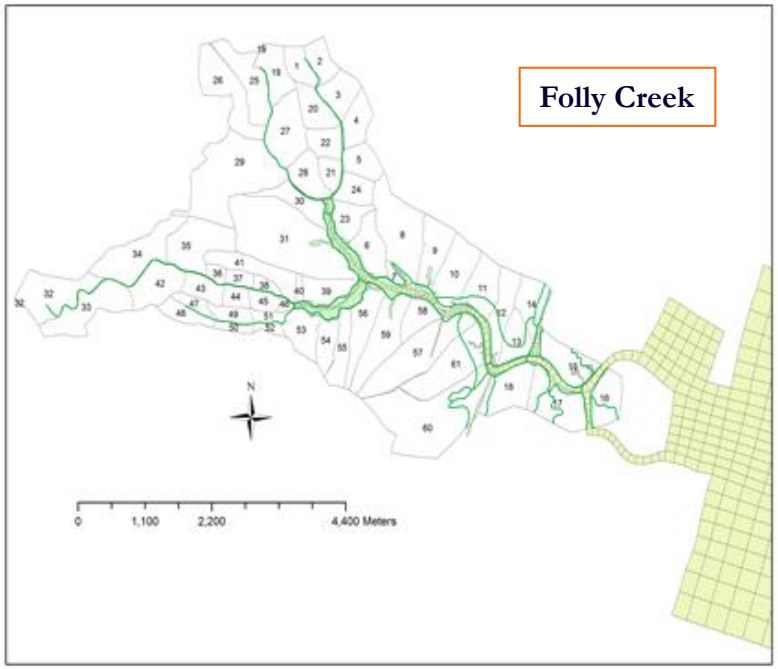


Model Simulation

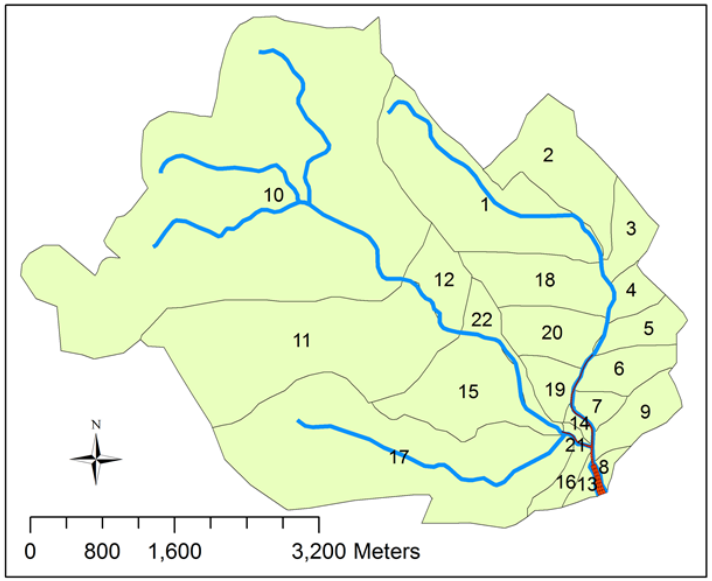
- Watershed Segmentation
  - Simulation flow, loading using Loading Simulation Program C++ (LSPC)
- Receiving water
  - grid generation
  - Simulate pollutant transport using Environmental Fluid Dynamic Computer Code (EFDC)
- Both models are supported by USEPA

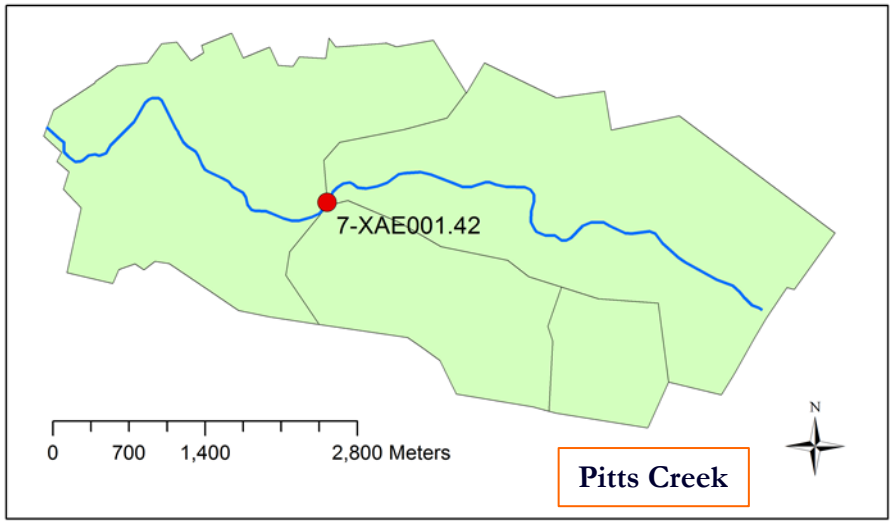
Watershed Segmentation and Model Grid

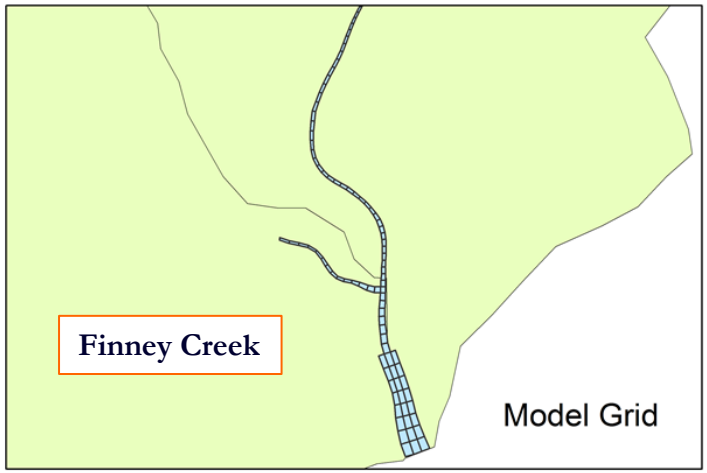




Watershed Segmentation and Model Grid







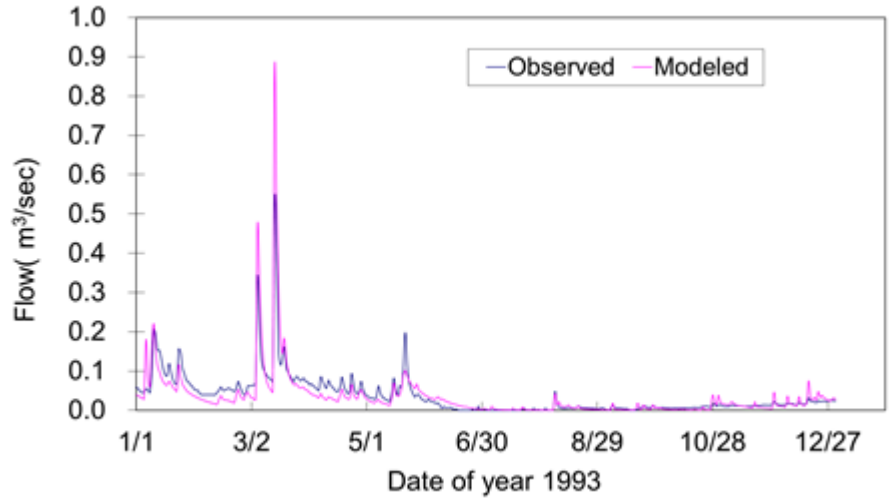
TMDL Development

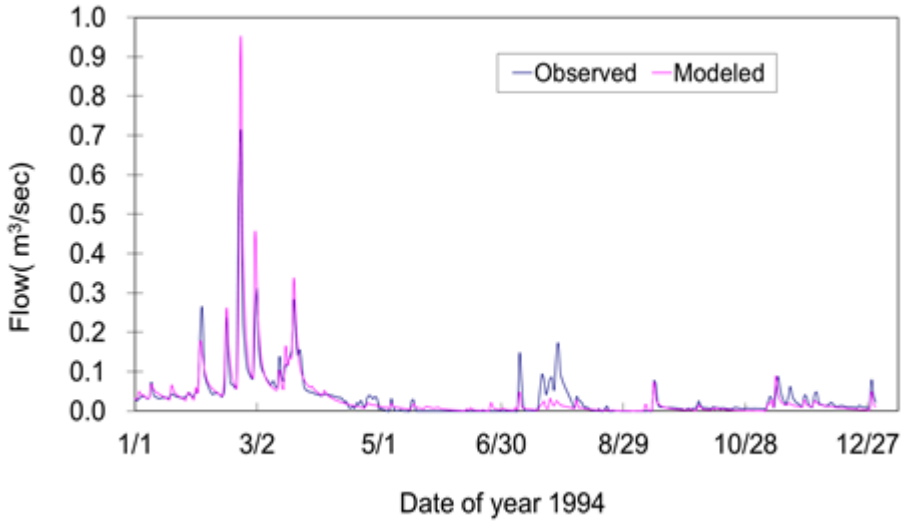
- Source analysis
- Use linked watershed and in-stream modeling approach
- Simulate daily nutrients and carbon loadings and bacteria loadings from watershed
- Discharge loads to in-stream model
- Use in-stream water quality model to simulate DO dynamics, and bacteria transport and fate
- Calibrate water quality model
- Compute allowable loads and determine load reduction

Preliminary Results of TMDLs

Stream Flow Calibration

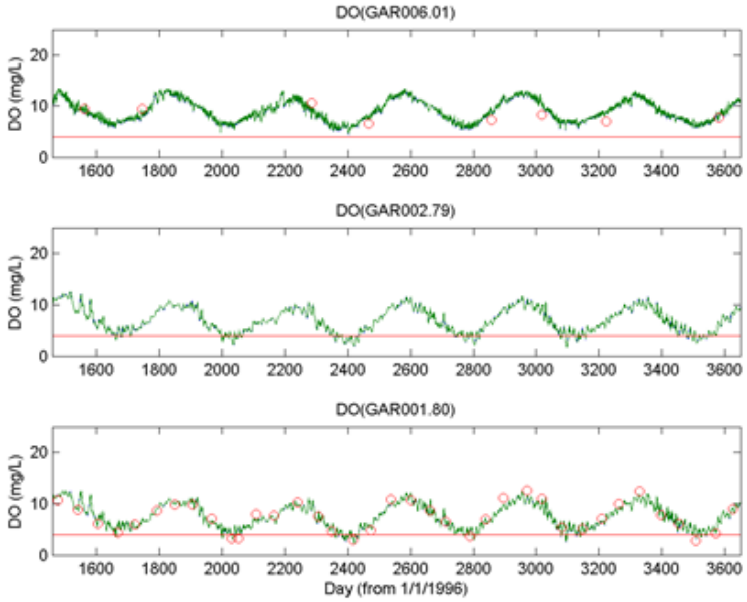
- USGS Stream Gage station (Guy Creek in Nassawadox) 01484800 in 1993 and 1994
- This gate station is the only gage station in Eastern Shore

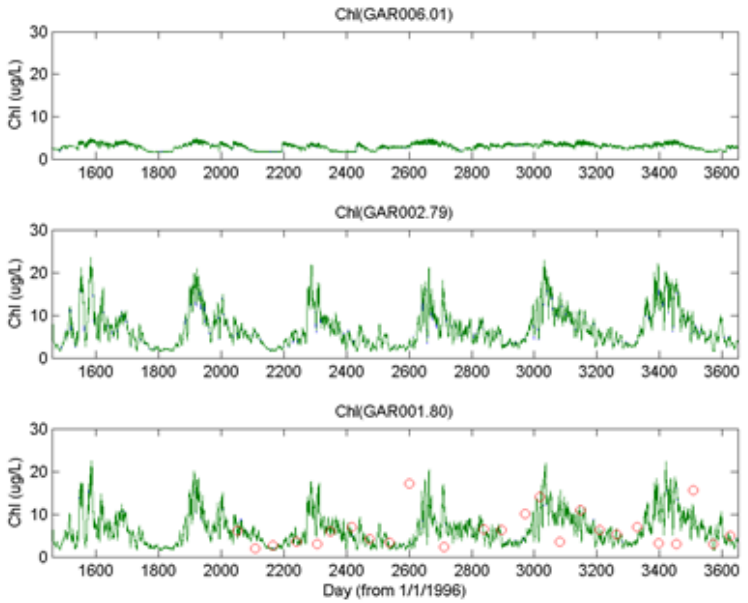




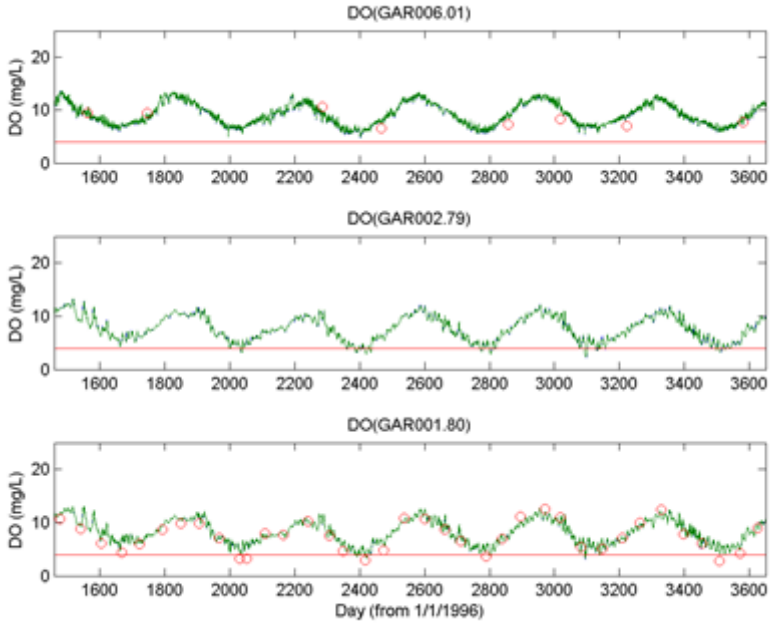
Example of Water Quality Model Calibration

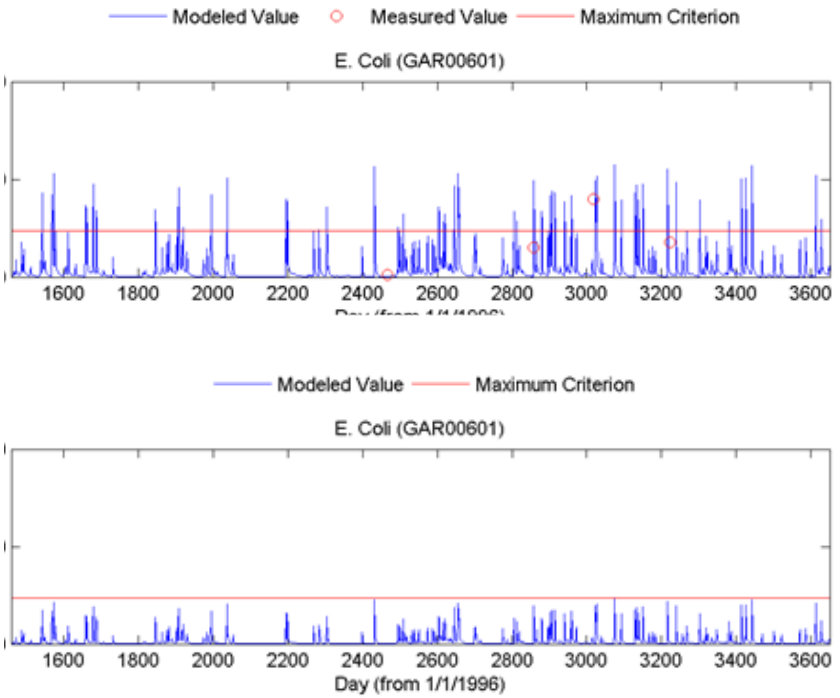
- Gargathy Creek



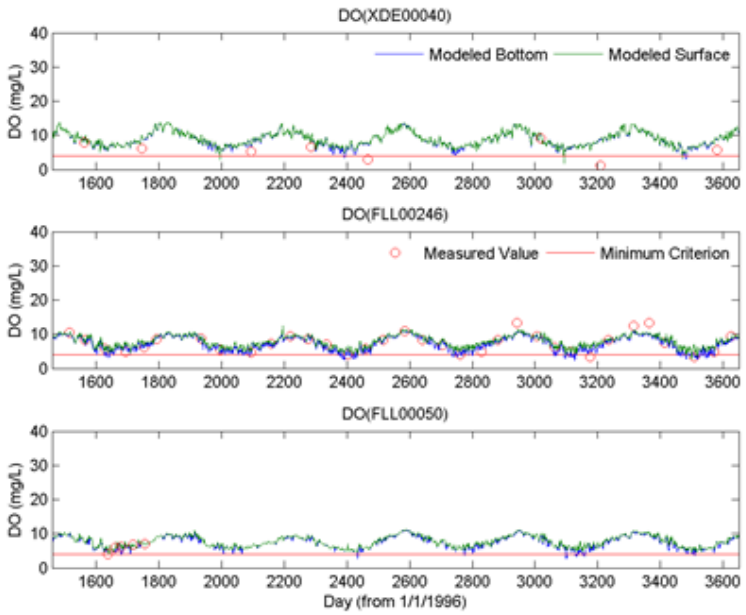


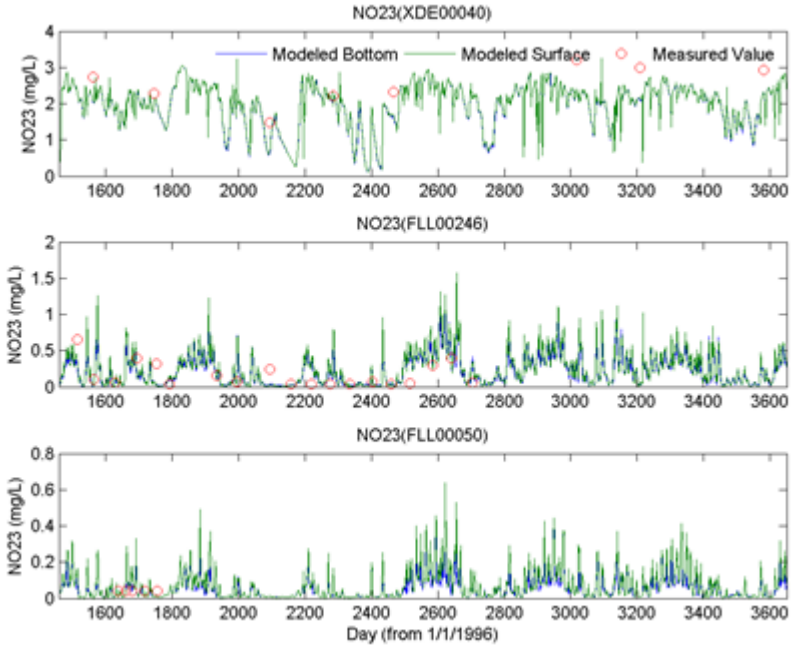
After Loading Reduction



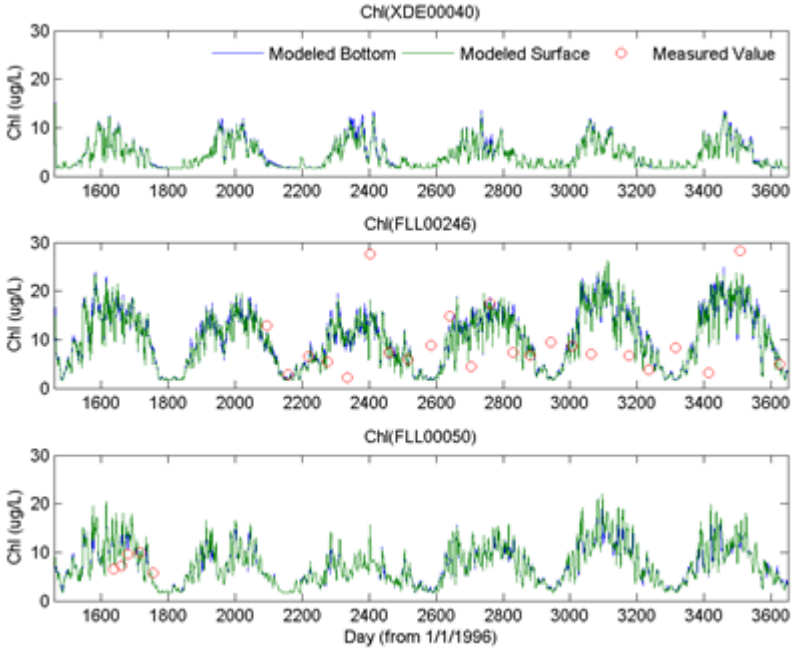


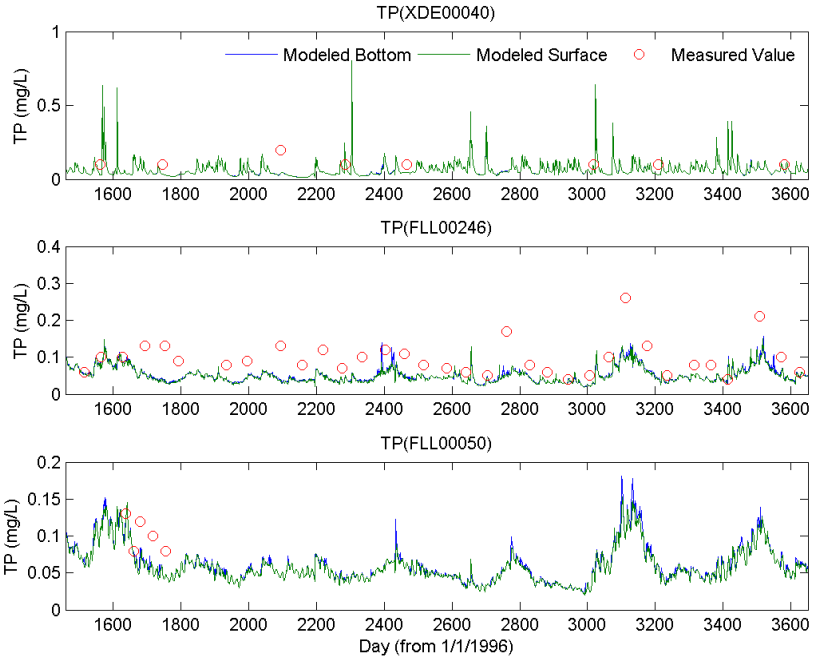
Folly Creek


DO(XDE00040)
Modeled Bottom
Modeled Surface
DO (mg/L)
DO(FLL00246)
Measured Value
Minimum Criterion
DO (mg/L)
DO(FLL00050)
DO (mg/L)
Day (from 1/1/1996)

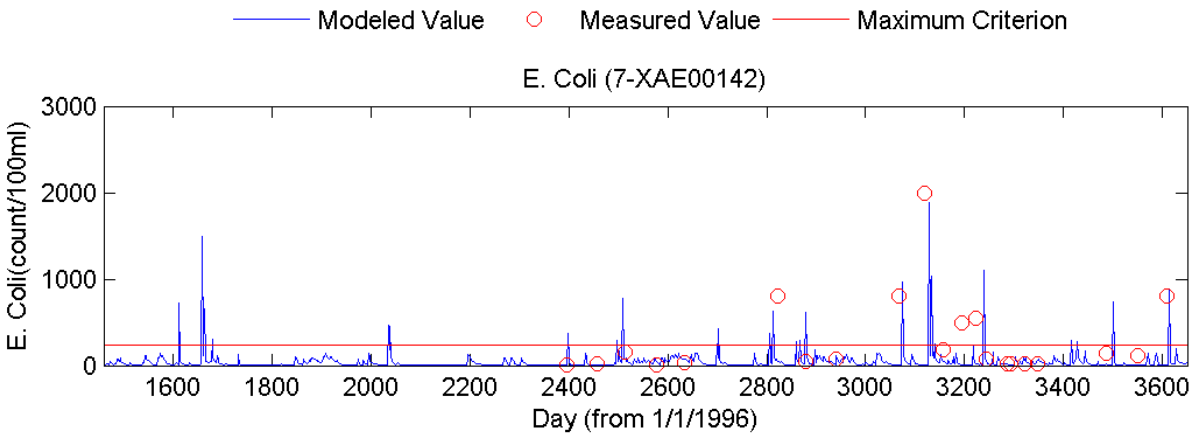

NO23(XDE00040)
Modeled Bottom
Modeled Surface
Measured Value
NO23 (mg/L)
NO23(FLL00246)
NO23 (mg/L)
NO23(FLL00050)
NO23 (mg/L)
Day (from 1/1/1996)

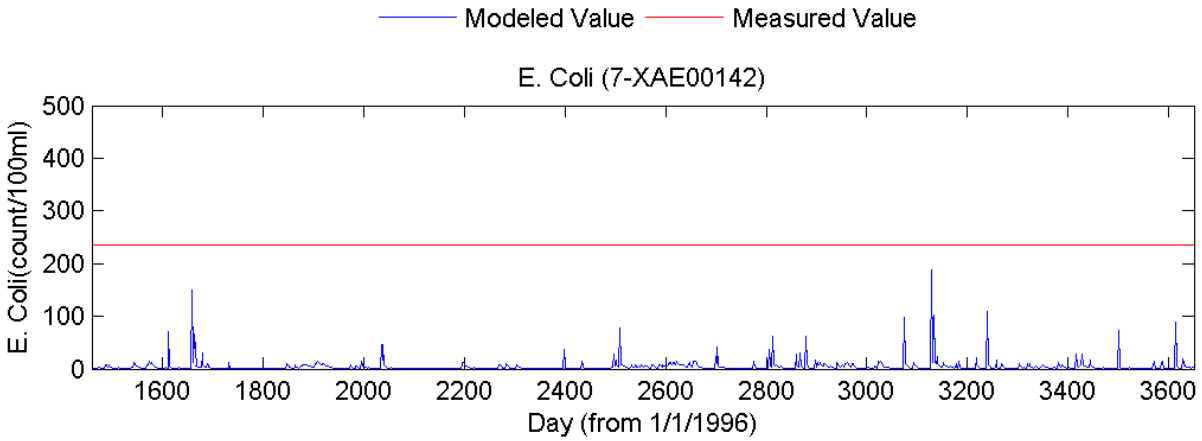
Folly Creek


Chl(XDE00040)
Modeled Bottom
Modeled Surface
Measured Value
Chl (ug/L)
Chl(FLL00246)
Chl (ug/L)
Chl(FLL00050)
Chl (ug/L)
Day (from 1/1/1996)

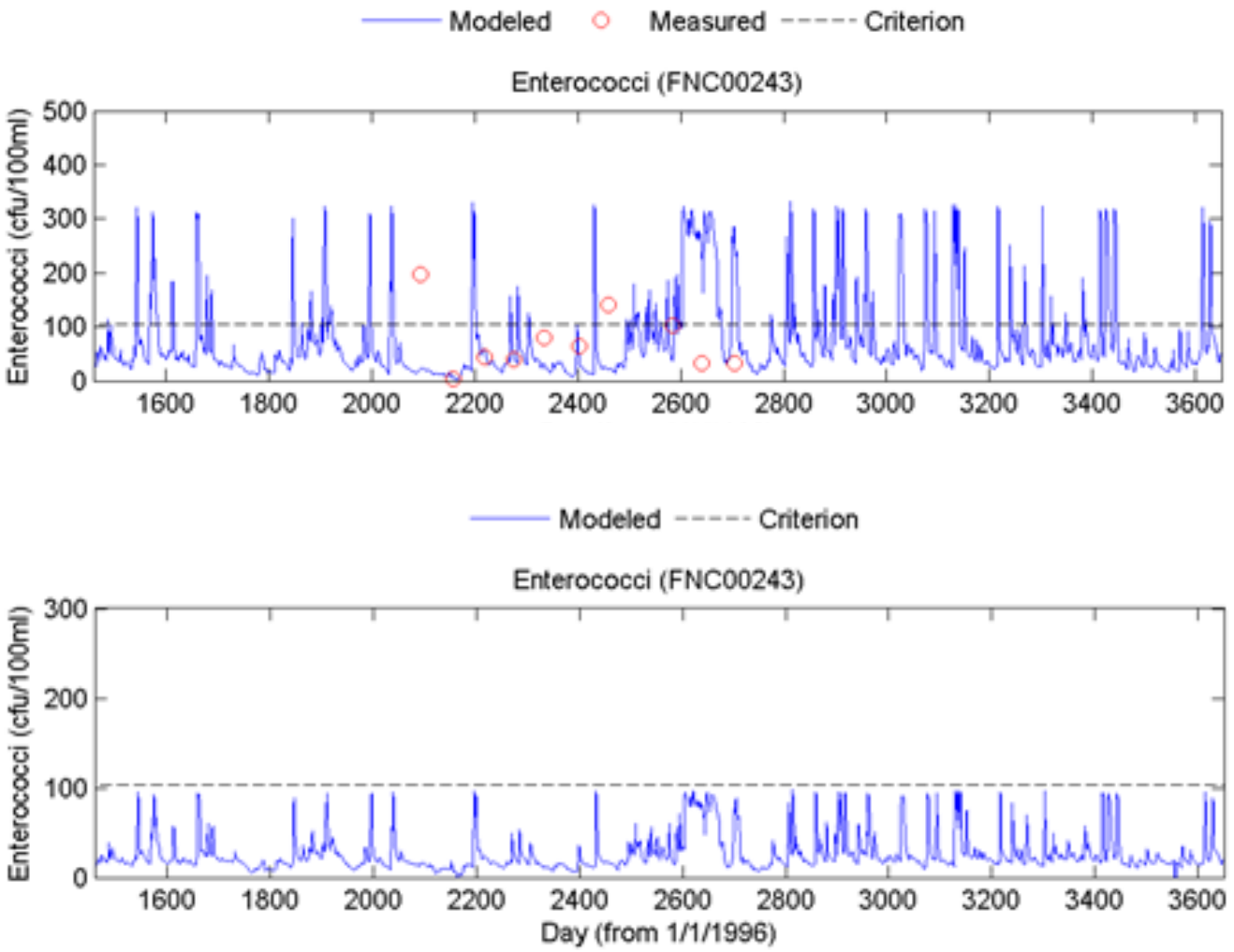

TP(XDE00040)
Modeled Bottom
Modeled Surface
Measured Value
TP (mg/L)
TP(FLL00246)
TP (mg/L)
TP(FLL00050)
TP (mg/L)
Day (from 1/1/1996)

Pitts Creek


Modeled Value
Measured Value
Maximum Criterion
E. Coli (7-XAE00142)
E. Coli(count/100ml)
3000
2000
1000
0
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Day (from 1/1/1996)


Modeled Value
Measured Value
E. Coli (7-XAE00142)
E. Coli(count/100ml)
500
400
300
200
100
0
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
Day (from 1/1/1996)

Finney Creek



Pitts Creek

Bacteria	TMDL	=	LA	+	WLA	+	FA	+	MOS
E. coli	6.39×10^{9}		6.00×10^{9}		n/a		6.4×10^{7}		3.2×10^{8}

TMDL =Total Maximum Daily Load
LA = Load Allocation (nonpoint source)
WLA =Wasteload Allocation (point source)
FA =Future Allocation (1% of the TMDL)
MOS =Margin of Safety

Category	Source Allocation	Current Load (Counts/Day)	Load Allocation (Counts/Day)	Required Reduction (%)
Livestock	15.48%	9.89E+09	0	100.00%
Wildlife	82.06%	5.24E+10	6.39E+09	87.81%
Human	0.01%	4.91E+06	0	100.00%
Pets	2.45%	1.57E+09	0	100.00%
Total	100.00%	6.39E+10	6.39E+09	90.00%

Gargathy Creek

Pollutant	Current Load (lb/day)	Allowable Load (lb/day)	Required Reduction (%)
TN	144.1	95.1	34

Pollutant	Criterion (counts/100ml)	Current Load (counts/day)	Allowable Load (counts/day)	Required Reduction (%)
E. coli	235	4.50×10^{10}	1.80×10^{10}	60

	TMDL	=	LA	+	WLA	+	FA	+	MOS (5%)
Total Nitrogen (lb/day)	95.1		90.4		n/a		n/a		4.7
E. coli (counts)	1.80×10^{10}		1.69×10^{10}				1.8×10^{8}		9.0×10^{8}

FA =Future Allocation (1% of the TMDL)

Category	Source Allocation	Current Load (Counts/Day)	Load Allocation (Counts/Day)	Required Reduction
Livestock	58.98%	2.65E+10	2.30E+08	99.14
Wildlife	39.49%	1.78E+10	1.78E+10	0.00
Human	0.01%	4.50E+06	0	100.00
Pets	1.51%	6.80E+08	0	100.00
Total	100.00%	4.50E+10	1.80E+10	60.00

Folly Creek

Pollutant	Current Load (lb/day)	Allowable Load (lb/day)	Required Reduction (%)
TN	201.65	131.1	35.0

	TMDL	=	LA	+	WLA	+	FA	+	MOS (5%)
Total Nitrogen	131.1		124.5		n/a		n/a		6.6

Where:

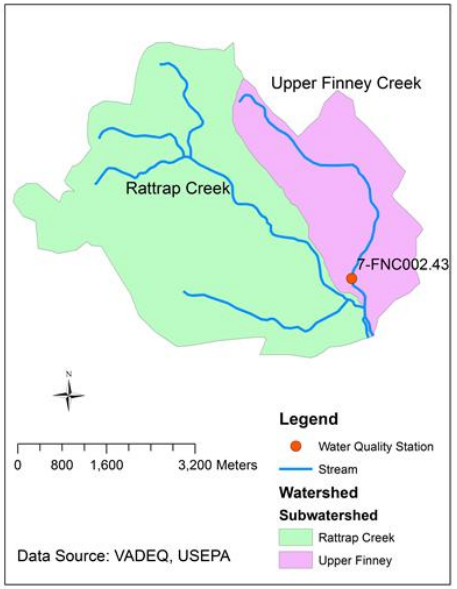
TMDL =Total Maximum Daily Load
LA = Load Allocation (nonpoint source)
WLA =Wasteload Allocation (point source)
FA =Future Allocation
MOS =Margin of Safety

Finney Creek

Waterbody Name		TMDL	=	LA	+	WLA	+	FA	+	MOS (5%)
Finney Creek	Enterococci	7.97×10^{9}		7.49×10^{9}		n/a		7.97×10^{7}		3.98×10^{8}
Rattrap Creek	Enterococci	2.08×10^{10}		1.95×10^{10}		n/a		2.08×10^{8}		1.04×10^{9}

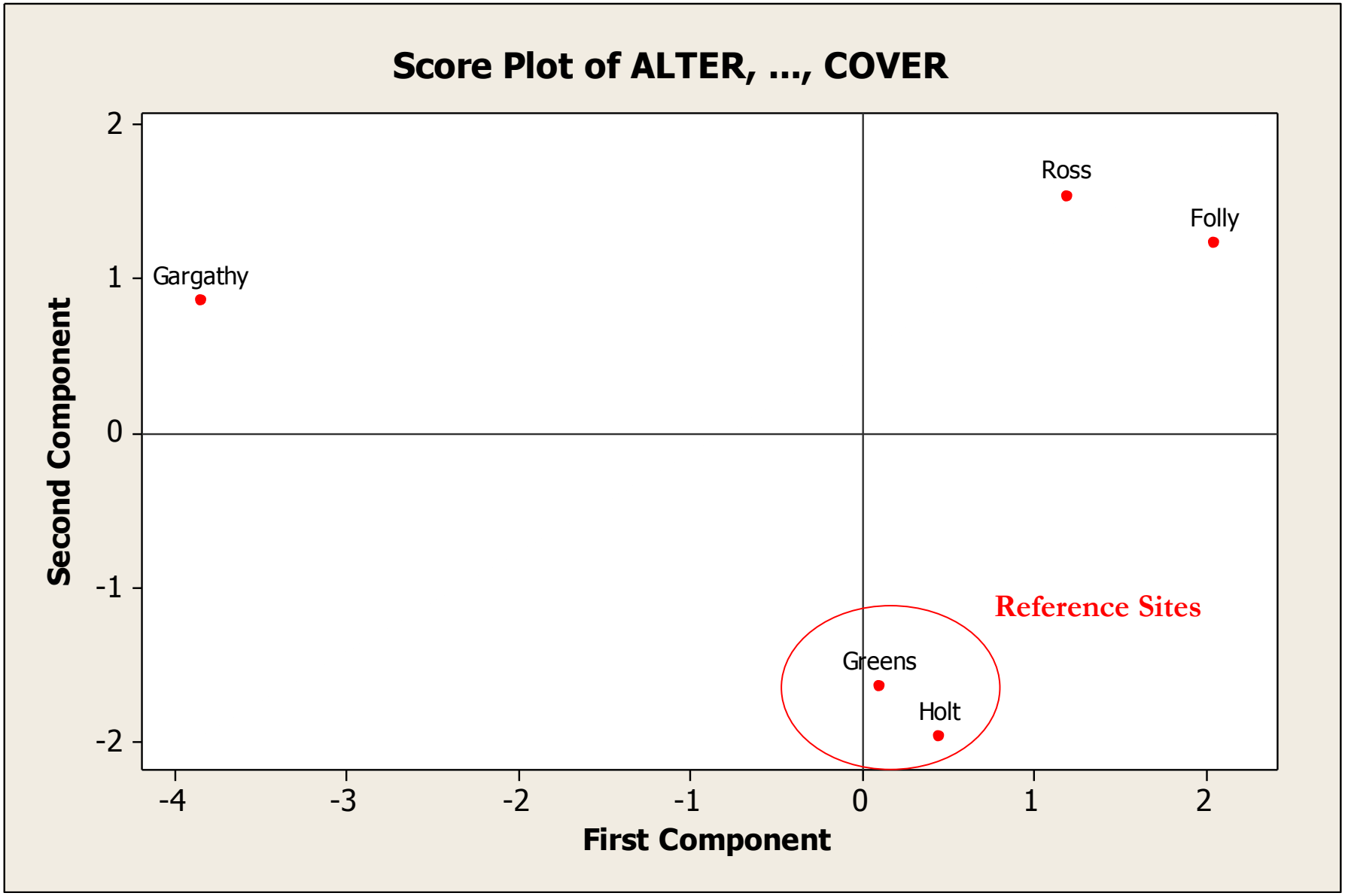
TMDL =Total Maximum Daily Load
LA = Load Allocation (nonpoint source)
WLA =Wasteload Allocation (point source)
FA =Future Allocation (1% of the TMDL)
MOS =Margin of Safety

Waterbody Name	Category	Current Load (Counts/Day)	Load Allocation (Counts/Day)	Reduction Needed (%)
Upper Finney Creek	**Livestock**	2.67E+09	0.00E+00	100.0%
	Wildlife	2.41E+10	7.97E+09	67.0%
	Human	3.94E+06	0.00E+00	100.0%
	Pets	3.26E+08	0.00E+00	100.0%
	Total	2.71E+10	7.97E+09	70.6%
Rattrap Creek	**Livestock**	7.02E+09	0.00E+00	100.0%
	Wildlife	5.65E+10	2.08E+10	63.3%
	Human	9.23E+06	0.00E+00	100.0%
	Pets	7.64E+08	0.00E+00	100.0%
	Total	6.43E+10	2.08E+10	67.7%



Benthic Impairment Analysis

- Conduct habitat analysis
  - Alter = Channel Alteration
  - Banks = Bank Stability
  - Bankveg = Bank Vegetative Protection
  - Flow = Channel Flow Status
  - Cover = Epifaunal Substrate/Available Cover
  - Poolvar = Pool Variability
  - Poolsub = Pool Substrate Characterization
  - Ripveg = Riparian Vegetative Zone Width
  - Sediment = Sediment Deposition
  - Substrate = Pool Substrate Characterization
- Conduct stressor basement


Score Plot of ALTER, ..., COVER
Second Component
First Component
2
1
0
-1
-2
-4
-3
-2
-1
0
1
2
Ross
Folly
Gargathy
Reference Sites
Greens
Holt

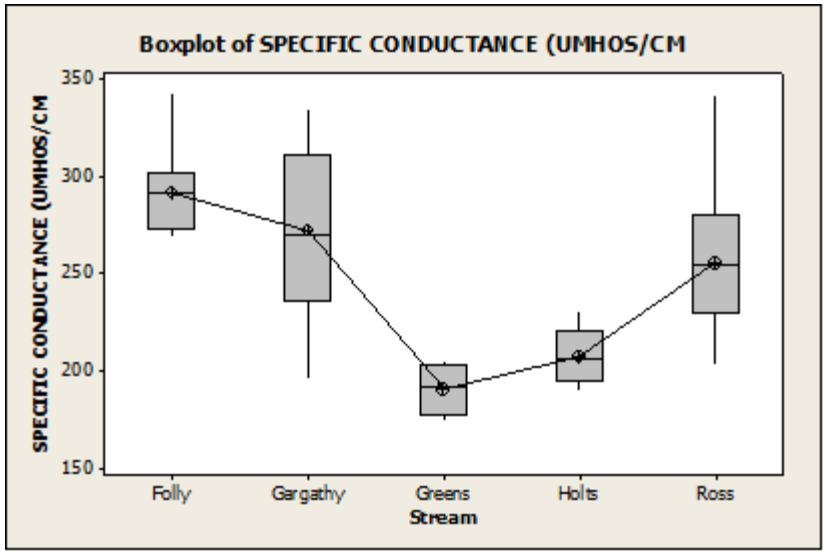
Habitat Degradation

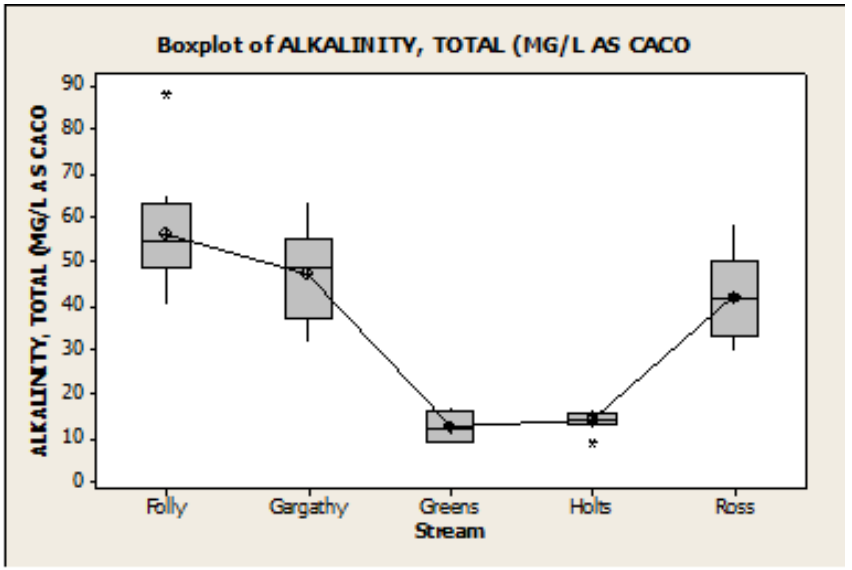
Variable	PC1	PC2
ALTER	0.351	0.052
BANKS	0.345	0.353
BANKVEG	0.115	-0.127
FLOW	0.396	-0.256
POOLSUB	0.362	-0.278
POOLVAR	0.333	0.369
RIPVEG	-0.111	0.043
SEDIMENT	0.398	0.061
SINUOSITY	0.263	0.453
SUBSTRATE	0.132	-0.420
COVER	0.298	-0.437

Gargathy	Folly	Ross
Sediment	Sin	
Flow	Flow	
Poolsub	Poolsub	
Alter	Alter	
Bank	Bank	

Statistics Analysis

- The ANOVA was applied to the available parameters for the 5 streams. The results show that only two parameters, conductance and alkalinity, are significantly different for the reference sites and impacted sites.
- There are no water quality standards for these 2 parameters and there are a number of factors that can cause change of these parameters.
- No violation for other monitoring parameters.
- More studies are needed.


Boxplot of SPECIFIC CONDUCTANCE (UMHOS/CM
SPECIFIC CONDUCTANCE (UMHOS/CM
350
300
250
200
150
Folly
Gargathy
Greens
Holts
Ross
Stream


Boxplot of ALKALINITY, TOTAL (MG/L AS CACO
ALKALINITY, TOTAL (MG/L AS CACO
90
80
70
60
50
40
30
20
10
0
*
*
Folly
Gargathy
Greens
Holts
Ross
Stream

Questions and Comments

- Source and Loading estimations ?
- TMDL calculation ?
- Other questions/comments ?

Comment period (July 19-Aug 17)

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Thanks!